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OFFICE OF CONTRACT ADMINISTRATION
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Date: 2/8/79

Project Title: A Cross Disciplinary Assessment of the Role of the Doctoral Dissertation in Career Productivity

Project No: E-24-679 (Sub-project is G-43-615/Chubin and Rossini/Soc Sci)

Project Director: Dr. Alan L. Porter

Sponsor: National Science Foundation

Agreement Period: From 11/1/78 Until ~~4/30/81~~ ~~6/30/81~~ 12/31/81 (Grant Period)

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Sponsor Contact Person (s):

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March 23, 1981

ANNUAL REPORT -- 1980 for Grant SRS78-18959
(GIT # E-24-679)

Dr. Gerald R. Glaser, Jr.
Division of Science Resources Studies
National Science Foundation
1800 G Street
Room L-611
Washington, DC 20550

Dear Dr. Glaser,

This report is intended to bring you up to date on the status of our project. We have tried to keep you abreast of our developments, so I don't think we need to go into great detail.

We are now working hard to finish our draft final report as per the outline I furnished about a month ago. Our strategy is still to think in terms of carefully targeted pieces that can emerge as articles addressed to the respective audiences. However, our final report main section will provide rather more detail as a central reference point for the project work. Things are moving smoothly and I hope we have the report in the mail to you next week.

I enclose copies of a comment based on the project that recently appeared in the American Psychologist.

When you have had a chance to look over our draft report, let's get in touch to discuss the possibility of a visit to D.C. to go over the findings in conjunction with final reporting.

Thanks for your support.

Best wishes,

Alan Porter
Principle Investigator

Georgia Institute of Technology

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FINAL REPORT

A CROSS-DISCIPLINARY ASSESSMENT OF THE ROLE OF THE DOCTORAL DISSERTATION IN CAREER DEVELOPMENT

Alan L. Porter
Daryl E. Chubin
Margaret E. Boeckmann
Terry Connolly
Frederick A. Rossini

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

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PART I—PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
Georgia Institute of Technology Industrial and Systems Engineering Atlanta, Georgia 30332	DSRS/STIA	SRS-7818959
	4. Award Period From 11-1-78 To 4-30-81	5. Cumulative Award Amount $71,290

6. Project Title extended to 12-31-81

A Cross Disciplinary Assessment of the Role of the Doctoral Dissertation in Career Productivity

PART II—SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

The study aimed to assess the doctoral dissertation as research and as a training instrument. A mail questionnaire was sent to 1969-70 PhDs in six fields: physics, biochemistry, zoology, electrical engineering, psychology, and sociology. Responses from 645 scientists (70% response rate) were analyzed, and their publication and citation histories were compiled. An informal phone survey of 25 "ABDs" (all but dissertation completed) provided another perspective.

Doctoral training is depicted as a process - commencing with a student's aim in seeking the PhD, addressing choice of program and dissertation topic, influenced by tangible (e.g., research facilities) and intangible (e.g., quality ratings of the department) features, heavily involving a mentor, and moving out beyond graduate training to early career considerations.

In scientific terms, the dissertation generates almost one publication directly and another 0.8 publications from continuation of the research, albeit only 50% publish from it directly and 26% from continuation. Dissertation-related publications are cited more than other publications of these respondents, implying that the work is scientifically interesting.

While PhD programs are research-oriented, only a minority of PhDs actively pursue research careers. Research facilities drop in quality from the PhD training facility to work settings. Very troubling is the profile of the psychologists to lowered research output within a decade of the PhD, apparently due to a number leaving research careers. There also appears to be a decline in publication activity from a 1963-64 cohort of psychologists to the 1969-70 group.

Not surprisingly, those pursuing research-oriented careers assess the dissertation positively. Yet, so do those not engaged actively in research. Little sentiment for change in graduate training practices emerged from any subgroup of respondents. This positive perception of doctoral training practices is notable, but it does not certify that current policies are optimal, especially for the majority of scientists who pursue teaching, professional practice, or administration.

PART III—TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM: Check (✓)	Approx. Date
a. Abstracts of Theses		✓			
b. Publication Citations		✓			
c. Data on Scientific Collaborators		✓			
d. Information on Inventions	✓				
e. Technical Description of Project and Results		✓			
f. Other *(specify)*					

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date

FINAL REPORT

A CROSS-DISCIPLINARY ASSESSMENT OF THE ROLE OF THE DOCTORAL DISSERTATION IN CAREER DEVELOPMENT

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Frederick A. Rossini

All with Georgia Institute of Technology
except Boeckmann, The Urban Institute

August, 1981

This material is based upon work supported by Grant #SRS78-18959, Division of Science Resources Studies, National Science Foundation; Project Monitor, Gerard R. Glaser, Jr. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation, the Georgia Institute of Technology, or the Urban Institute.

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Appendix N. The Doctoral Dissertation: Role in Research and Non-Research Careers (A. L. Porter, D. E. Chubin, F. A. Rossini, M. E. Boeckmann, and T. Connolly, Science, to be submitted)

ACKNOWLEDGEMENTS

We have many to thank beginning with Gerard Glaser, our patient project monitor at the National Science Foundation (NSF) who offered significant help and support. Lindsey Harmon and the Board on Human-Resource Data and Analyses of the National Research Council (National Academy of Sciences) provided critical formative guidance and priceless service in determining a "unique names" sample. Dael Wolfle and Joseph McCarthy of the University of Washington consulted and guided us insightfully throughout. Kenneth V. Anderson helped us relate to the biosciences in concept and practice. Penelope Jacks found and interviewed the "ABDs." Patricia McBride worked on the study of men and women psychologists. David Mayer assisted in running the project for two years; Henry Bell, Denise Ford, and Don Van Cleave also contributed substantially. Loren P. Rees and Choon Y. Park set up and executed many computer analyses. Henry Small of the Institute for Scientific Information helped structure and conduct the citation search. Muriel Quinones of NRC provided helpful data. Mary Jo Clark, Ed Conlon, Tom Gieryn, Dan Livingston, Loren Rees, John Ryan, Mike Shlesinger, and Joyce Sween reviewed multiple questionnaire drafts and advised us in sundry ways. F. Binkley, Jim Bynum, Bill Eberhardt, Ron Fox, Tom Gieryn, Donald Groth, Joseph Kinkade, Barry Langermann, Keith Legg, Craig Little, Nancy Love, Morris Mitzner, John Norgard, Randall Packer, Sal Restivo, Martin Ribarsky, Bob Rice, A. C. Scarbrough, Raymond Shapiro, Daniel Sullivan, Charlie Vail, Henry Wilbur, Alfred Wilhelm, Gerrit Wolf, Bernie Zahuranec, and others also reviewed pilot materials for us. Lastly, Vicki DeLoach typed and managed preparation of the survey materials and the array of manuscripts masterfully. Without her aid, the project would have been a nightmare.

INTRODUCTION

This report summarizes 30 months of work on a single issue: the role of the doctoral dissertation in career development. The problems with research on such a well-circumscribed issue stem from its embeddedness in, and connections to, larger issues. These issues originate in the process of graduate education in the U.S. of which the dissertation is the capstone experience. To study the preparation and evaluation of the dissertation apart from its cultural and educational contexts, therefore, would be senseless - convenient, but irrelevant to prospective planning, understanding, and policy assessment.

Orientation

Our "sensible" approach recognizes that the dissertation reflects on several related issues, each with an identifiable literature and tradition of research. Our approach traces the dissertation from its precursors in graduate training procedures to post-PhD activities that occur within the first decade of the scientist's professional career. Such tracing was done through reconstruction. That is, patterns of activities were sought retrospectively, using as sources of information various documents in the public domain as well as primary data collected expressly for this study from those whose careers we chose to reconstruct. Without such self-reported or "subjective" survey data to complement archival information, we reasoned, the mechanisms that underlie career decisions and patterns remain obscure.

Below we discuss the data files we assembled and how information was compiled from extant archives and through the cooperation of fellow scientists; we wish to emphasize the uniqueness of these files. Although publication, citation, and even employment information could be retrieved from indexes and directories, rarely has information specifically on the dissertation - as an experience and a prelude to scientific work - been compiled. Our six-page mail questionnaire sent in Feb. 1979 to Spring, 1979, to a random sample of 1969-70 PhD recipients from U.S. universities did not remedy this lacuna forever, but it did allow us to probe certain dimensions of the graduate training experience that had not been scrutinized before. Nor had the relationship between this "terminal research training" experience, production of the doctoral dissertation, and later "productivity," ever been explained. The assumption that what is learned in graduate school is utilized in one's career precluded, with a single exception,[1] systematic study.

This project, then, was intended to collect and analyze information on "assumed relationships" that were not uniformly sustained by the Porter and Wolfle study of psychologists cited above. Our aim was to extend their disciplinary focus and link it to the demography and reward system literatures on scientific careers. To do so with the compendia of data we sought to develop would afford us the empirical leverage necessary for conducting policy analysis. That is, our expectation was not merely to describe, but to predict. If we could present rationale, methods, and predictions built upon a comprehensive theoretical base, then the products, as well as the process, of our analyses would be of policy use. It is not our indicators *per se*, but their ingredients which hold promise of contributing to the study of scientific career patterns and the formulation of policy therein.

The first of the two literatures on which our study draws conceives of careers in science as a demographic problem. A highly-trained labor force is deployed into a market composed of employment sectors, objectives, and work roles (e.g., Harmon[2]). A scientist's movement within the marketplace, between institutions, and between work roles forms a sequence of patterned events and experiences we call a "career." However, the contingencies which yield patterns are numerous. What are they? Are the different career paths we observe substantially fixed at the scientist's professional origin? And along which dimensions - discipline, institution of training, career orientation - do they vary?

Whereas the demographic approach to careers focuses upon aggregate patterns which evolve over time, a second literature devoted to career patterns takes another tack. It embraces a reward system approach (à la Merton) assuming high motivation and creativity among doctorate scientists, and focusing on the performance and recognition that careers represent. What, in short, is valued by the scientific institution and its culture? Again, the answers differ - as do the patterns - with the sectors, institutions, and roles in which scientists array themselves. Research is viewed as synonymous with productivity. Yet an observation made decades ago still looms: as many as half the PhDs who pursue a career in science - irrespective of field - never publish.[3] For many, then, science is a non-research activity which features work and rewards that depart in character from the stereotype. Again, are such inclinations imparted in graduate school? Is the doctoral dissertation an early warning that a scientist's forte is <u>not</u> research or that other kinds of productive work or career path, e.g., those outside the academic archetype, is apt to be sought? And if doctorate scientists are trained in skills they rarely employ throughout their careers, then should not the research orientation of the PhD degree be reassessed, modified, and/or replaced by other creative and marketable skills? Are not scarce resources and energies being wasted? Is there a more efficacious way to specialize training requirements in accordance with evidence that a fuller spectrum of professional models are pursued by doctorate scientists? Indeed, are not alternative definitions and measures of productivity needed to capture this fuller spectrum of scientific careers?

Organization of the Report

With the scope and guiding questions of the study in mind, we can proceed to its substance. Several caveats, however, are in order. First, throughout the report the term "scientific career" appears. It should be remembered that our perspective is restricted to the "early" career, namely, the first post-PhD decade which represents one-quarter to one-third of the years spanned, by contemporary standards, by a career in science.

Second, although we have relied extensively on the information provided by our 645 survey respondents, we are cognizant of the fallibility of such data. Retrospective accounts of career experiences over a ten-year period are subject to the omissions, juxtapositions, and embellishments of scientists' recollections.[4] One's more recent experiences serve as a selective filter to color - accentuating and leveling - perceptions, especially those elicited in response to closed- and open-ended questions about the memorable, emotionally-intense time in the neophyte scientist's life that the writing of a dissertation creates. Rather, we regard the survey responses as affording insights into processes, motives, and intentions - the very behaviors which all-too-routinely are attributed to scientists in the absence of their direct measurement.

Third, a key unit of analysis and element of our approach is the field or discipline. Six fields were selected - including physical, biological, and social sciences as well as one engineering discipline - and used to stratify our random sample. Although this is the least aggregated level of analysis, it is not the only level, as various "cuts" at the "dissertation-productivity" relations outlined above were made. We report these in more or less detail, as the findings warrant.

What follows, then, are four major sections on:

- Description of the Data Set
- The Route to the PhD
- Value of the Dissertation, and
- Predicting Early Career Stature.

In a final conclusions and recommendations section, indicators and models will be offered as summary interpretations and predictions for further study with other sampled cohorts, disciplines, and data sets. For now, we are mindful of the policy concerns which initially prompted our proposal to NSF/SRS. As stated there:

1) How is the dissertation "selected, guided, and produced relative to its worth in training future scientists and engineers"?

2) What are the "relationships between characteristics of the dissertation process and the scientific value of the dissertation"?

3) How do "graduate education experiences and postdoctoral opportunities" bear upon career productivity?

4) What is the "attractiveness of certain alternatives to the doctorate," especially to "those intending to pursue teaching-focused or non-academic careers"?

In addition to the body of this report, we have appended several papers. These include disciplinary analyses, comments (published and forthcoming) on career issues in the literature to which our data speak, the highlights of an M.S. thesis replicating K. Wilson's[5] classic "time and the doctorate" study, and two conceptual papers based, respectively, on phone interviews with a small sample of ABDs (those who completed all requirements for the doctorate except the dissertation) and on comments proferred by our survey respondents on the relationship between mentors (or major professors/dissertation supervisors) and students (i.e., themselves).

CHARACTERISTICS OF THE SAMPLE OF 1969-70 PhDs

The Sample

The two key sources of data for this analysis are a mail survey of 1969-70 PhDs and a compilation of publication and citation information for the respondents through 1978. The survey was restricted to six fields, reflecting interest in a sample sufficient to produce useful generalizations of findings for each field within practical study resource limitations. The six fields were chosen to span the National Research Council categories of science-based doctorate recipients:

- Physics (a physical science)
- Biochemistry (a basic medical science)
- Zoology (another, non-basic-medical, biological science)
- Electrical Engineering (engineering)
- Psychology (a main subheading of the social sciences)
- Sociology (a non-psychology social science).[6]

The target was 100 respondents/field with a 67% response rate. To generate such a sample we began by randomly drawing about 400/field (2438 viable names), who received their degrees in 1969 or 1970, from the 1970 Dissertation Abstracts.[7] The National Research Council (NRC) then kindly matched this list with their combined work tape (consisting of the Dissertation Records File, fellowship holders, and miscellaneous scientists) to ascertain which of our cohort members had unique last names and initials so as to reduce the homograph (duplicate name) problem in publication and citation counts.[8] We randomly selected from the resultant 1510, who matched the NRC file exactly once, to yield about 200/field.[9] We then sought addresses for these, drawing upon the National Faculty Directory, respective professional society directories (e.g., American Psychological Association), the Science Citation Index (SCI) and Social Science Citation Index (SSCI), and contact with the schools awarding the PhDs (departments and/or alumni offices).[10] Usable responses were obtained[11] from 645 PhDs (see Table 1 for field counts) for an overall response rate of 70.0%.[10]

Publication and citation information was gathered through a multistep process. We first searched the SCI and SSCI Source Indexes for publications by the 1198 persons in the sample for whom we sought addresses.[9] These were keypunched, then reproduced as a special coversheet that went on the questionnaire, requesting respondents to correct and augment the publication information.[12] They were asked to estimate the person-months of effort invested in each and to categorize the publications as:

1) pre-dissertation
2) directly taken from the dissertation
3) resulting from continuation of the dissertation, or
4) other post-PhD work not directly associated with the dissertation.

Citation information was then sought through two parallel routes. The SCI for 1970 through 1978[13] was searched by the Institute for Scientific Information for each publication using an automated program.[14] Concurrently, we searched the SSCI by hand.[15] Citations were then consolidated into a single file.[16]

Response bias is always a concern in surveys such as this. Thus, we compared a number of dimensions with "population" estimates. The NRC has compiled information on a number of characteristics of doctorate holders

Table 1. Basic Respondent Characteristics

Field	N	% Female	% Married at Doctorate	Median Age at Doctorate[b]	Median Total Time from Bachelors to Doctorate[c] (Mean)	% with Masters Degree[d]	Median Full Time Equivalent (FTE) Months in Doctoral Program	Median FTE Months on Dissertation	Median Calendar Months on Dissertation
Physics	97	2.1	84.5	28.9	6.8 (7.5)	81.4[d] (72.2)	50.8	23.8	26.2
Biochemistry	119	16.8	77.1	27.4	5.5 (6.4)	54.3[d] (42.0)	48.2	23.8	29.9
Zoology	123	2.4	78.7	28.9	6.6 (7.9)	84.5[d] (75.6)	42.2	20.1	29.8
Electrical Engineering	106	0.9	76.0	29.0	6.8 (8.1)	94.7[d] (84.0)	36.0	12.3	18.4
Psychology	107	24.3	71.7	28.2	5.7 (6.8)	84.4[d] (75.7)	44.9	9.5	13.8
Sociology	93	18.3	80.2	33.3	9.1 (10.3)	89.0[d] (78.5)	39.7	12.3	18.1
Total[a]	645	10.7	77.9	28.9	6.0 (7.8)	81.4 (70.7)	44.9	14.7	23.9

Field	% Describing Federal Financial Support as Instrumental[e]: Grant	Fellowship/Traineeship	% Held Postdoctoral Fellowship or Temporary Research Assistantship	Mean FTE Years Employed Since PhD: Academic	Business	Government	Other	% of Time Devoted to Research (± Standard Deviation): First Year Post-PhD Job	Current Job
Physics	81.1	41.2	40.2	4.9	2.6	1.5	0.5	58.1±41.2	32.5±34.3
Biochemistry	89.1	73.1	72.3	5.7	1.6	0.9	0.6	85.0±30.2	57.3±31.6
Zoology	65.0	56.1	41.5	8.2	0.3	0.7	0.2	43.8±39.0	34.7±28.5
Electrical Engineering	56.3	49.0	9.5	2.6	5.7	0.9	0.4	43.1±34.6	24.6±27.1
Psychology	44.3	63.2	26.2	5.3	0.7	1.8	1.7	26.3±29.5	18.7±22.9
Sociology	26.7	32.6	18.5	8.6	0.2	0.4	0.5	25.5±24.1	30.9±26.6
Total[a]	61.6	53.7	35.9	5.9	1.8	1.0	0.6	48.0±39.5	33.7±31.3

[a]See Note 6.

[b]We approximate by subtracting birth year from graduation year.

[c]Based on responses (N = 487) giving year of bachelors degrees (when 2 such, we use the first listed), subtracted from graduation year.

[d]This value is probably an overestimate in that it is based on the responses to "Post-secondary degrees other than the PhD" (N = 560), and most non-respondents probably had no such degrees. The value in parentheses, on the other hand, divides the positive responses by the total field size and is an underestimate.

[e]Questions concerned whether federal fellowship or traineeship was instrumental to pursuit of the doctorate; whether federal research grant support (to self or faculty) was instrumental to dissertation work.

over time. As shown in Table 1, our sample responses represent the following percentages of the Fiscal Year 1970 doctorates awarded: physics - 5.7%, biochemistry - 20.5%, zoology - 36.1%, electrical engineering - 15.0%, psychology - 5.7%, and sociology - 18.4%.[17] The observed patterns of % female, % married at doctorate, median age at doctorate, median total time from bachelor's to doctorate, % with master's degrees, and % engaged in postdoctoral study ("intent" in the NRC records) closely correspond with NRC tallies.[18] We next compared respondents with (1) non-respondents and (2) with those not effectively addressed (e.g., 70 for whom we found no address, 113 with foreign addresses, 67 undeliverables, and 24 others for miscellaneous reasons). Using the initial listing of publications as an unbiased comparison, we found a statistically significant difference (F = 3.67, p = .026) with the 645 respondents highest at a mean of 6.46 (median 3.62), 273 non-respondents close at 5.96 (median 2.54), and 274 others not addressed lagging at 4.81 (median 2.12). The difference between our respondents and non-respondents is small (t = 0.76, n.s.). Our respondents thus seem to slightly overrepresent those active in scientific research.[19] On other dimensions examined - quality ratings of PhD institution[20] - geographical region, and year of degree (1969 or 1970), there were no significant differences among the three groups.

Basic Respondent Characteristics

Upon examining Table 1 further, we find that biochemists and psychologists seem to attain their doctorates at the youngest age, taking the least time from their bachelor's degrees. They seem, however, to follow rather different graduate training paths with psychologists devoting the least time of the six fields to the dissertation (9.5 FTE months) while biochemists devote the most (23.8 FTE months - tied with physics). The dissertation thus appears to play a larger (and earlier - 74% of the biochemists began their dissertation in the early or middle stages of coursework for the doctorate vs. only 26% of the psychologists) role for the biochemists. The pattern seems to generalize with the social sciences represented in the study devoting less time to the dissertation and starting on it later (only 22% of the sociologists began by middle coursework); the physical sciences spending more time and starting earlier (dissertation begun by mid-coursework by 38% of the physicists, 82% of the zoologists, with electrical engineers at 40%).

Accounting for time is made cumbersome by figuring in master's degrees (separate or not?), but note that the master's is the modal rule - with biochemists least apt to acquire (about 50%) and all other fields at about 80% or more. Keeping in mind this variation, we observe that it takes almost 4 years from the baccalaureate (median 44.94 months, mean 44.72, with a sizable standard deviation of 15.31 months) to earn a doctorate degree. Of that, about 15 months on average are devoted to work on the dissertation per se (median 14.69, mean 17.58 ± 11.82). In general, the dissertation takes about 1 year (FTE) in the social sciences and engineering fields sampled, and almost 2 years in the physical sciences.

Federal financial support was quite important to these 1969-70 PhDs. Support was extensive in the physical sciences, least in sociology. The dominant mechanism of support varies from research grants sustaining graduate students in the natural sciences to fellowships or traineeships in the social sciences. Differential policy implications thus attend to these support mechanisms.

Postdoctoral appointments are another important stage in the neophyte scientists' careers. This mechanism is the modal choice in the basic biomedical science represented in our study - biochemistry; only a small minority secure such appointments in psychology, sociology, and electrical engineering. We will return to the issue of postdoctoral positions in considering what contributes most to career research productivity.

The early careers of our 1969-70 PhDs bear no surprises, but do point out the divergent sectoral directions taken. Academia was the dominant employer by a large margin in every field except electrical engineering, but especially in zoology and sociology. However, many of the respondents did not follow the classical academic path - for instance, 35.7% spent less than half their FTE employment in academia, including 23.5% with no academic work (N = 151 of the 642 responding to this item). Furthermore, the extent of research activity shows great variability and a rather striking decline during the first decade (except for sociologists). This finding, too, raises questions concerning the quirks of the PhD process with respect to non-classical (academic, research-oriented) career routes.

The PhD: A Research Degree?

Some comments received from our respondents offered a mild reproach for some of our questions, for instance, as one sociologist put it:

> I do not believe doctoral training should be considered by, or for, persons not interested in doing research. Persons who want the PhD primarily for career advancement might better obtain the "degree" from a mail order establishment.

The tone, as much as the words, suggests that, of course, the PhD is a research-oriented degree. A number of those who administer and study graduate education concur. Spriestersbach emphasizes "that I am not challenging the definition of the Ph.D. as a research degree" in a critique of the role of the dissertation.[21] He summarizes the description of the

PhD by the Council of Graduate Schools as

> the mark of highest achievement in preparation for creative scholarship and research, often in association with a career in teaching at a university or a college. The Doctor of Philosophy shall be open as a research degree in all fields of learning, pure and applied.

(The last sentence has been a statement of general policy tracing back to the Association of American Universities in 1904.) The University of Michigan dissertation review committee likewise asserted "One line of reasoning approaches consensus more closely than any other. It proceeds as follows: The Doctorate of Philosophy is a research degree. It should be no more and no less."[22]

Our survey yields evidence that this blanket position oversimplifies a significantly more complex reality. We asked how important were each of various career aims - research, teaching, professional practice, or other - in the decision to seek a PhD. On average, research as an aim nudges out teaching (mean of 3.71 vs. 3.64 on 5-point scales from not important to very important). However in sociology and zoology, teaching is the stronger motivation; in psychology, teaching and professional service lead research. One electrical engineer asked rhetorically: "The question should be 'Why get into a doctoral program?' and the answer was 'to teach.'" Looking solely at strong responses, the maximum of the non-research aims tends to be more compelling than research overall: 76.2% of respondents indicated a non-research aim at 4 or 5, vs. only 58.3% so indicating for research. However, the most compelling result is a tally of the percentage of respondents for whom research was an unimportant career aim (1 or 2 on the 5-point scale), <u>dominated</u> by another aim (at 4 or 5):

- physics - 17.2%
- biochemistry - 10.8%

- zoology - 21.6%
- electrical engineering - 19.2%
- psychology - 38.1%
- sociology - 38.1%

[overall - 23.5%]

In sum, for almost a quarter of these PhDs, research was not at all the reason for attaining the degree.[23]

Should one accept that the PhD is not strictly a research degree, the focus of concern points to the dissertation, as it serves as the central vehicle for 'learning research by doing it.' Interestingly, the dissertation was not always so; prior to the scientific revolution the thesis meant some kind of public performance that served as a means of evaluating prospective teachers. There was no trace of the assumption "that it ought to result in an original contribution to a body of knowledge."[24] In the modern era, the thesis has eroded as a requirement for the master's degree and dissatisfaction with the dissertation for the PhD has surfaced.[25] As one weighs relevance and cost, there would seem "room for improvement in our rationalization of the places of research in the education of our graduate students;" ". . . the thesis is a good servant, but a bad master."[26]

As we proceed to investigate the role of the dissertation, we should not assume that all doctoral graduates are training for research careers.[27] Rather, we may join Bowers[28] in posing a harsh challenge:

> whether the essential training of the research elite to develop their peculiar capacities is worth what is, no doubt, the over-training of the majority who shortly discover that they have no marked talent for continued original research of any magnitude.

THE ROUTE TO THE PhD

Having presented some basic aspects of the sample of 1969-70 PhDs, we now review their graduate training experiences as captured by the survey results.

Field-Shifting

The field of the bachelor's degree was provided by 479 respondents. An interesting profile emerges in terms of diversity:

- physics - 93% bachelor's in physics
- biochemistry - 51% chemistry, 15% biochemistry, 26% life sciences (= 92% in sum)
- zoology - 42% zoology, 51% other life sciences (= 93% in sum)
- electrical Engineering - 77% electrical engineering, 15% other engineering (= 92% in sum)
- psychology - 75% psychology, 14% other social sciences (= 89% in sum)
- sociology - 29% sociology, 35% psychology or other social sciences (= 64% in sum).

Graduate training in physics seems to attract the most disciplinarily homogeneous array of students; sociology, by far the least. Biochemistry is more heterogeneous, while zoology either draws a diverse lot or not depending on how sharply one sees the disciplinary boundaries in the life sciences.[29]

The significance of such educational "field-switching" (e.g., physics to chemistry) can be appreciated when post-PhD specialization (e.g., solid state physics to plasma physics) is considered. The 1969-70 PhDs exhibit a great degree of specialty shifting from their dissertation area to their primary professional identity a decade later. Of the 532 respondents providing both pieces of information, half (49.2%) had changed specialization during that period. Most stable were those in zoology, electrical engineering, and biochemistry at about 57% the same, followed by sociology at 47%, physics at 42%, and psychology at 40%. (Much of the psychology shift is due to the discrepancy between dissertation subject - e.g., personality - and clinical or counseling specialization for 39% of the subjects.) While specialty shifting is common, the shifts are generally not radical; some 78.8% still identify with their PhD field after a decade. Moreover, even those changing fields typically make neighborly switches. For instance, field loyalty is lowest in the two life sciences (67.6% still zoology; 68.9% still biochemistry), but few wander too far. Of the field-switching biochemists (we deemed molecular biology to be a non-switch), 10 are in medical science, 11 in other life sciences, 6 in chemistry, and 1 in library/information sciences. Overall, only about 4% made radical field switches (to such areas as education, professional fields, art, theology, etc.). It thus seems likely that the graduate training received remains generally relevant for nearly all these PhDs; one might wonder, however, about the relevance of the dissertation. Indeed, the percentages indicating their dissertation to be highly relevant (4 or 5 on a 1-5 scale from not at all to very much relevant) to their present work activity (and even to their work activity on their first post-PhD job) are strikingly low:

- physics: 19.4% after 9-10 years (38.3% to first job activity)
- biochemistry: 27.8% (41.0%)
- zoology: 45.5% (50.0%)
- electrical engineering: 23.8% (40.6%)
- psychology: 15.7% (32.1%)
- sociology: 32.9% (34.1%)
- overall: 27.7% (39.7%)

Institution-Shifting

The folk wisdom of science holds that the prospective graduate student ought to shift institutions from his or her undergraduate school. What happens with our cohort is interesting to note. Only about half (54%) of our sample could be said to follow the same field from bachelor's through PhD. Overall about 1 out of 6 (16.7%) of the respondents denoting bachelor's institution (N = 496) remained there for their PhDs. (The folklore is effective!) The only deviation is among the electrical engineers, with 25.3% staying on at their undergraduate schools. That this reflects a less national or cosmopolitan outlook is supported by a second statistic - the % of students remaining in the state of their bachelor's degree for their PhD, but at a different school; the engineers were again the highest (by a small margin at 17.7%; overall average 15.3%). Remaining at the same school (or remaining in state at a different campus) showed essentially no disparities in terms of whether the person attended a highly ranked graduate school (Roose-Andersen rating[20] - 4 or over; 3-4; or other), pursued an academic career (% FTE employed academic), became a productive researcher (3 or more articles, books, chapters, or proceedings), or pursued a career now emphasizing research, teaching, or other activities. There was neither a discernible average "creaming" to keep the best undergraduates at one's school nor the reverse. That has certainly not been the case for first job hiring at elite institutions.[30]

Quality Rating of Graduate Departments

One of the more studied attributes of graduate training, of course, is the prestige of the institution and the implications thereof. We are able to examine various implications of prestige on the course of graduate school and early career developments, drawing on the Roose-Andersen peer ratings conducted at the time our respondents were completing their doctorates.[20] Most of the PhDs graduated from mid-ranked departments, with women tending slightly (non-significantly) toward the extreme categories (Table 2).

Roose-Andersen ratings differentiated respondents in a number of ways, pointing to one important overall distinction. Not surprisingly, reputation of university, of department, and of specialty area were significantly more important in selection of the particular PhD program as respondents' departmental rating rose - and situational factors were less important. In contrast, the importance of a particular faculty member (intended dissertation supervisor) in the selection of one's PhD program ran generally inversely with departmental prestige[31] (Table 2). This suggests that, to some degree, PhD students are attracted to weakly rated programs by individual faculty members. It further implies that students attending such programs may be more discerning, not less, than their peers at more highly rated departments (one must beware a possible respondent hindsight halo effect). To the extent this is verified, it would suggest that graduate student recruiting at the non-elite departments might begin with faculty recruiting. The relation of Roose-Andersen rating to the graduate training progression is intriguing, both in terms of negative and positive findings. Departmental prestige did not significantly differentiate on most factors, including sources of financial aid (although students at the lowest rated schools were less apt to have research assistantships, 17.2%, than those at other schools, 28.8%, as the primary financial support during the dissertation research). Though confounded with student ability differences, the higher-rated schools appear to exert a greater influence toward a

Table 2. Department Rating and Selected Characteristics

Quality of the Graduate Faculty[a]	Men N[b] (%)	Women N[b] (%)	Importance of Intent To Do Dissertation Research with a Certain Faculty Member in Selection of PhD Program[c]	Career Publications (Mean)[d]
4.00 - 5.00	63 (11.6)	11 (17.5)	2.73	9.99
3.00 - 3.99	205 (37.9)	19 (30.2)	2.54	9.69
2.00 - 2.99	191 (35.3)	19 (30.2)	2.77	6.94
0.01 - 1.99	82 (15.2)	14 (22.2)	3.18	5.54
Total	541	63	2.74 (N=575)	8.11

[a]The faculty raters could indicate: distinguished (5), strong (4), good (3), adequate (2), marginal (1), or not sufficient for doctoral training (0). Of the programs rated in our six fields, 30.8% averaged 3.00 or better, 36.8% 2.00-2.99, and 32.3% less than 2.00. The higher rated programs produce proportionately more PhDs; the lower rated ones, fewer.

[b]No ratings were available for 41 of our respondents' departments.

[c]Values are means adjusted on a 1 (not important) to 5 (very important) scale for field and sex in an ANOVA; see Note 31.

[d]Articles, books, book chapters, and proceedings.

research career. As one attended a higher-rated department, he or she was more apt to

- have a prominent supervisor (adjusted $\bar{X} = 1.76$ for the 4.00 and over departments on a 1-4 scale from 1 = renowned [top 5% nationally in specialty] to 4 = not prominent, moving linearly to 2.63 for the under 2.00 departments - an interesting contrast to the selection criterion of individual faculty)
- receive slightly more supervision
- find research advice from other graduate students and seminars helpful
- find employment related to the dissertation, yet take longer on the dissertation and in the doctoral program
- have better research facilities (current facilities better too)
- receive help from the dissertation supervisor in obtaining the first post-PhD job
- carry the dissertation research forward after graduation, and
- produce significantly more career publications through the first decade (Table 2).

Career Aims

We now describe a series of graduate training aspects in terms of our respondents, then attempt to relate these to the dissertation experience. The first aspect one might consider is why someone chooses to seek a PhD. We queried our respondents on the importance of career aims in this regard. As shown in Table 3, research and teaching are approximately equal, strong aims with the two most academically oriented professions (zoology and sociology) emphasizing teaching. Professional practice is a strong third factor in electrical engineering (47 of 98 respondents to that item rated it important)

Table 3. Graduate Program Aspects

Field	Preparing for Research-oriented Career Important in Seeking PhD[a] (%)	Preparing for Teaching Career Important in Seeking PhD[a] (%)	Primary Financial Support During Dissertation Research: % Fellowship	Primary Financial Support During Dissertation Research: % Research Assistantship	Inherent Personal Interest Important in Choice of Dissertation Topic[a] (%)	Faculty Preference Importance in Choice of Dissertation Topic[a] (%)
Physics	70.5	53.8	18.6	58.8	55.8	65.3
Biochemistry	81.4	49.1	48.7	28.2	48.3	68.6
Zoology	62.2	76.0	39.7	17.4	75.6	36.9
Electrical Engineering	58.4	39.6	31.4	22.9	60.6	48.1
Psychology	47.5	50.0	36.3	14.7	66.3	34.7
Sociology	40.5	76.4	25.3	17.6	66.7	40.7
Total	61.2	57.6	34.1	26.2	62.3	49.1

Field	Type of Dissertation[b]: Theoretical (vs. Empirical/Experimental)	Type of Dissertation[b]: Lab (vs. Field)	Type of Dissertation[b]: Basic (vs. Applied)	Supervisor Involvement: Co-Authorship	Supervisor Involvement: Important in Obtaining First Post-PhD Job[a]
Physics	0.27	6.10	10.12	65.3	31.2
Biochemistry	0.08	8.82	9.60	91.4	37.2
Zoology	0.12	1.31	4.94	45.5	26.5
Electrical Engineering	1.61	5.62	0.57	60.4	15.8
Psychology	0.26	2.28	1.88	44.3	20.2
Sociology	0.22	0.22	1.42	26.1	22.2
Total	0.30	2.12	2.73	56.6	25.9

Field	Helpfulness of Various Graduate Training Resources[c]: Seminars	Graduate Students	Other Professionals	Technicians and Non-Professionals	Adequacy of Research Facilities[d]: Dissertation Research	Adequacy of Research Facilities[d]: Current	Importance in Evaluation of the Dissertation[a]: Originality	Significance	Positi Findin
Physics	31.2	43.2	44.3	29.3	81.2	56.2	55.9	54.9	46.1
Biochemistry	55.1	39.0	41.9	21.6	84.0	79.0	65.0	59.3	59.8
Zoology	54.5	49.6	49.2	13.6	74.6	47.6	73.0	61.5	48.8
Electrical Engineering	28.6	22.1	33.0	6.3	70.7	65.9	71.2	55.8	49.5
Psychology	40.4	25.0	32.7	18.6	74.8	40.3	51.9	43.8	33.3
Sociology	30.0	29.7	30.0	26.7	73.3	48.8	60.7	43.8	24.4
Total	41.0	35.3	39.0	19.1	76.6	57.1[d]	63.4	53.7	44.6

[a] "Important" = responses of 4 or 5 on a scale from 1 = not important to 5 = very important.

[b] Figures given are the ratio of "1" and "2" responses to "4" and "5" responses on 1-5 scales; 1.0 would represent perfect balance.

[c] "Helpfulness" = responses of 4 or 5 on a scale from 1 = not at all to 5 = very helpful.

[d] Adequacy indicated by responses of 4 or 5 on a scale from 1 = not satisfactory to 5 = very satisfactory. We note that a sizable percentage of respondents indicated current research facilities to be "not applicable." If they were included in the total tally on the presumption that the facilities are not satisfactory the percentage "adequate" would drop from 57.1 to 47.6. (In contrast, the drop for dissertation facilities would be slight, to 75.3%).

and in psychology (53 of 100), but not in general (only 64 for the other 4 fields combined). The model of the PhD as a research-oriented degree seems sharpest in the two "hardest" sciences represented. It is not so clear in the majority of the fields - teaching dominates research in sociology and zoology; professional practice and teaching together dominate research in psychology and electrical engineering. One might begin to wonder if graduate training practices adequately balance these several student career aims.

Program Selection

How do prospective PhD students select a particular program? We inquired about the importance of six factors, with the following results:

- reputation of the university ($\bar{X}$ = 3.48; 51.2% "important," responding 4 or 5 on a scale from 1 = not important to 5 = very important)
- reputation of the department ($\bar{X}$ = 3.64; 56.0% "important")
- specific reputation of strength in intended specialty ($\bar{X}$ = 3.40; 49.6% "important")
- intent to do dissertation with certain faculty member ($\bar{X}$ = 2.76; 38.2% "important")
- financial support ($\bar{X}$ = 3.52; 58.8% "important")
- situational factors ($\bar{X}$ = 3.25; 50.9% "important").

Choice thus appears to entail a balancing among multiple important factors; no single factor dominates. Zoologists report greatest sensitivity to specific specialty strength and individual faculty, followed by the engineers. Least sensitive to these factors by over 1 unit removed from the zoologists (on 1-5 scales) were the physicists, with the psychologists engineers, less so to the biochemists and zoologists (difference of ... 0.8 units). Women were significantly less sensitive than men to the reputational factors, but more sensitive to situational factors. Most surprisingly, this difference holds for single (N = 44) and "other" (e.g., divorced; N = 4) women but not for married women. Married women (N = 20) were slightly less influenced by situational factors than either single or married men and were as sensitive to reputational factors as well. Marital dependence does not explain this interesting sex difference.

Financial Support

Financial support is of concern because of its amenability to policy manipulation. Table 3 gives tallies of the percentages of respondents noting fellowships or research assistantships as providing the largest portion of financial support during the dissertation research. Of course, our PhDs attended graduate school during a period of strong federal support, including the NDEA fellowships and NSF and NIH traineeships provided to universities to spread support among many new or enlarging graduate programs. The physical sciences appear relatively blessed during this period. Another measure corroborates this with respect to federal largesse - some form of federal research grant support was deemed instrumental to pursuit of the doctorate by 89.1% of the biochemists and 81.1% of the physicists, 65.0% of the zoologists, 56.3% of the electrical engineers, 44.3% of the psychologists, and only 26.7% of the sociologists. Federal fellowships were somewhat more pronounced for two fields - psychology (63.2% deemed instrumental) and sociology (32.6%). Research assistantships predominate over other forms of support for physicists to a degree not seen in the other five fields. Of course, most people draw on multiple sources of support over the course of graduate training. We attempted to profile these by offering 8 named possibilities as primary or secondary sources during the research phase and during writing. Results suggest cross-field differences, particularly with the extent of full-time employment. This is the most-named support during dissertation writing by the sociologists (40 of 92) and second to fellowships during the research (26 vs. 33 mentions). It tied for most-mentioned with fellowships by psychologists during the writing (31 mentions by 101 persons) and was not uncommon during writing for engineers (29 of 105) and zoologists (23 of 118). In contrast, such full-time work was rare for biochemists (6 of 115) and physicists (10 of 92). Results imply that performing the dissertation research on a part-time basis is the case for a substantial minority in sociology, electrical engineering, and psychology - but rarely so in the other fields represented.

Dissertation Topic Selection and Type

We were concerned as well about what prompts a student to select a particular dissertation topic. The ideal might be student dedication to a major scientific contribution, but as suggested in the introduction, this may be balanced against feasibility and faculty preferences. Overall findings would rank factors as follows:

1) Inherent personal interest ($\bar{X}$ = 3.70; 62.3% "important," responding 4 or 5 on a scale from 1 = not important to 5 = very important)
2) Scientific importance ($\bar{X}$ = 3.40; 46.6%)
3) Faculty (supervisor) preference ($\bar{X}$ = 3.25; 49.1%)
4) A manageable study to fulfill requirements ($\bar{X}$ = 3.10; 45.7%)
5) Environmental considerations (e.g., financial assistance, lab facilities) ($\bar{X}$ = 2.91; 39.6%).

The image suggested is of a balancing among factors, but a reassuring general ordering favoring pursuit of student scientific interests over performing a research exercise to fulfill requirements or someone else's interests. Of course there is tremendous individual variation. One physicist commented: "Topics in our research group were essentially assigned by the supervisor," while another noted: "My advisor let me follow my own ideas. After a short period of directed reading, I found my own thesis topic." Field contrasts are significant for three of the factors. Manageability is a strong concern of the electrical engineers (59.6% say "important") ranging down to only 36.9% "important" for zoologists and 30.8% for biochemists. (Though not statistically significant, field differences on scientific importance as a criterion show the engineers lagging at 38.1% important with the zoologists leading at 51.2%). As shown in Table 3, personal preference overshadows faculty preference generally - but not for the physicists and biochemists. This does not appear to be simply reflecting an arrangement whereby graduate students who work in a particular faculty member's lab over an extended period tailor their dissertation to fit the research agenda (the lab vs. field distinction does not significantly discriminate the degree of faculty preference).

We next inquire as to the character of the dissertation. Not surprisingly we find that dissertations are overwhelmingly individual efforts, although a few (58 of 627 responding) indicated serious collaboration involved (4 or 5 on a 1-5 scale). As presented in Table 3, dissertations tend to be more empirical than theoretical, but more basic than applied, and more often conducted in the lab than the field (when such characterizations are sensible). Most surprising is the result that electrical engineers are the only field represented to characterize their dissertations as more theoretical than empirical, on average. This variable had been included explicitly to tap the presumed split among physicists, which emerged only modestly (only 14 physicists rated their dissertations as "1," only 4 as "2" on the 1-5 scale). Yet while dissertations tend to involve empirical work, they tend also to be seen as basic rather than applied in character, with the engineers again providing the sole exception (not a surprise). The typical electrical engineer, thus, sees his (only 1 woman in the sample) dissertation as theoretical but applied; all other fields see theirs as empirical but basic, on average. Sociology is the only field in which field research dominates lab work, although zoology and psychology have significant minorities (respectively, 32.0% and 27.4% rated their work 4 or 5 on 1-5 scales).

Supervision

A key element in the process of preparing a dissertation is the supervision received. We posed a number of questions on supervision. In general dissertations are guided by a committee and its chairperson. For 90.8% of our respondents, the chairperson was also the supervisor of the research. In 98.4% of the cases the supervisor held regular faculty rank (58.6% professor, 27.7% associate professor, 12.1% assistant professor). Presented with a 4-point scale: 1 = renowned (among the top 5% nationally in specialty), 2 = eminent (top 20% nationally), 3 = established, and 4 = not prominent, respondents perceived their supervisors as nearly eminent on average ($\bar{X} = 2.34$). (Zoology indicating most eminence at $\bar{X} = 2.10$.) The supervisors were estimated to have guided a striking number of dissertations: $\bar{X} = 12.54$ (median = 6.18) to completion; $\bar{X} = 3.39$ (median = 2.83) others in progress. The median number in progress under one supervisor, including a count of 1 for our respondent, ranged narrowly from 3.45 in psychology to 4.64 in zoology. Thus, the average faculty member supervising dissertations was guiding about 4 concurrently. The median number guided to completion ranged more widely from a high of about 10 in the social sciences (10.07 in sociology; 9.88 in psychology) to a low of about 3-4 in the "hard" sciences (3.62 in physics; 3.86 in biochemistry - with electrical engineering at 4.80 and zoology at 8.00). The strong impression, therefore, is that graduate students distribute themselves very unevenly among prospective faculty advisors. The logistics are rather compelling. For instance, our prominence rating suggested category 1 as the top 5% nationally; category 2 as the next 15%; even allowing for a fair bit of wishful stretching in gauging one's advisor, the percentages are much beyond those levels - 21.2% category 1; 34.1% category 2. Likewise admitting to possible errors in estimating PhDs guided to completion, the tallies are rather staggering with means far outdistancing medians (e.g., $\bar{X} = 16.99$ in psychology vs. median of 9.88). When one glances at the respondents' employment profile to note that it is about 60% academic, it is clear that there would be a staggering academic population explosion were all faculty advising near the indicated number of PhD candidates. The implied distribution is highly skewed - PhD students gravitate toward particular, more eminent faculty members in large numbers; a few, quite experienced professors guide many PhD students; many professors must guide none or very few students.

Yet one might wonder how much supervision is provided. A substantial percentage (17.1%) responded "minimal throughout" (1 on a 6-point scale); on the other hand 24.2% responded "heavy throughout" or "almost daily" (5 or 6 on that scale). There was essentially no difference in the amount of supervision by the perceived eminence of the supervisor. Curiously, however, the supervision provided by committees where the supervisor was considered not prominent was notably lower ($\bar{X} = 1.34$ vs. an overall mean of 1.67 on a scale from 1 = minimal to 6 = almost daily) - possibly reflecting committee feelings toward the supervisor. While not statistically significant, zoology shows the greatest tendency for weak supervision by the supervisor (22.1% minimal; only 18.0% heavy or almost daily), (it also showed the greatest personal say in the dissertation); sociology shows the most supervision (13.0% minimal; 30.4% heavy or almost daily).

Our earlier study of psychologists[32] had found a relative lack of committee involvement in the dissertation supervision and evaluation processes. This study extends that negative finding to other fields. Some individuals emphasized how little a committee can mean. A zoologist commented "I never had a thesis committee meeting." A physicist added: "Once a dissertation is approved by the advisor, it is 'rubber-stamped' by the others on the committee." Nowhere did committees play a heavy role in supervision (defined as significant interaction with 1 or more members other than the supervisor); the range was from 4.3% in physics and biochemistry to 1.9% in engineering, with an overall average of 3.5% heavy involvement (67.7% overall at minimal throughout). Median values serve also to contrast the involvement of the supervisor (3.70 - with 3 as significant at the initial and final stages, 4 as moderate throughout) with that of the rest of the committee (1.24 - with 2 as significant at completion only). One might ponder the value of the committee at such low levels of involvement.

The strength of the role of the PhD supervisor, given the low involvement of the committee and the powerlessness of the student, can lead to abuse. Occasional comments bear this out. In the words of one "ABD" (all but dissertation) (see Appendix L): "He was a son of a bitch; if I wanted to ask him a question, he'd say 'make an appointment,' but he was the only person working in the area."

Given the potential sources for conflict among student, supervisor, and committee, it is reassuring to report that conflict was rare for our respondents - only 11.7% reported any serious conflicts (4 or 5 on a 1-5 scale from no serious to very serious conflict) between student and supervisor, student and other committee members, or among the committee members including the supervisor. However, this is not to say that departments need not watch for problems. For instance, one psychologist stated: "Conflict with my supervisors was so intense that my dissertation and the area of research became aversive."

Likewise, we can report that students were inspired/stimulated by their supervisors to a considerable degree (median 3.84; 59.4% 4 or 5 on a 5-point scale from 1 = not at all to 5 = very much). One physicist offered that: "He [supervisor] has had a strong influence in shaping me, both in professional and non-professional areas - a very positive force in my life."

The extent of supervisor supervision and the inspiration attributed shows an anomaly across fields. Zoology supervisors provide the least supervision (median 3.28 on 1-6 scale vs. overall median 3.70), yet the greatest inspiration/stimulation (median 4.14 on 1-5 scale; overall median 3.84). Zoology committee members also are more inspirational than those in other fields (median 2.60 vs. overall median 2.13) without providing noticeable supervision (median 1.30 on 1-6 scale; overall median 1.24).

Two other opportunities for supervisor involvement in the doctoral student's early career are publication co-authorship and aid in obtaining the first post-PhD job. Table 3 indicates that co-authorship practices vary dramatically from being the overwhelming mode in biochemistry to relatively rare in sociology. Important assistance in obtaining the first job was attributed more often to biochemistry supervisors as well, with least assistance in electrical engineering. Of course, mentor involvement is apt to be greatest in securing post-doctoral appointments which are most common in biochemistry and least common in electrical engineering.

Table 4 shows the correlations among five supervisor attributes. More prominent supervisors are reported to be more inspiring and more helpful in obtaining the first job. A supervisor providing more supervision is more likely to become a co-author and to help in securing the first job. (The relationship between extent of committee supervision and inspiration is even stronger - $\tau = .428$.) Inspiration, co-authorship, and helpfulness in obtaining the first job also all intercorrelate. The implication here is that a student should seek out a prominent supervisor willing and able to provide ample supervision.

Other Sources of Help and Facilities

Four other attributes were considered in terms of their helpfulness to the dissertation work/doctoral training. Overall, they ranked as follows:

1) Seminars, research group meetings, student colloquia ($\bar{X} = 3.06$; 41% "helpful," responding 4 or 5 on a scale from 1 = not at all to 5 = very helpful)
2) Research advice and assistance from other professionals (e.g., faculty other than committee members, post-doctoral personnel, senior research staff) ($\bar{X} = 3.02$; 39.0%)
3) Research advice and assistance from graduate students ($\bar{X} = 2.94$; 35.3%)

Table 4. Correlations Among Supervisor Attributes

	Degree of Supervision	Inspiration/ Stimulation	Co-Authorship	Helpfulness in Obtaining First Post-PhD Job
Perceived Prominence	-.004	.215	.026	.254
Degree of Supervision		.331	.084	.115
Inspiration/Stimulation of Respondent			.150	.238
Co-authorship with Respondent				.155

Note: Coefficients are Kendall's tau, preferred because these ordinal measures have many tied ranks. All are significant at the .001 level (1-tailed test) except for the -.004 and .026 values which are not significant at the .1 level.

4) Research assistance from technicians and non-professionals ($\bar{X} = 2.20$; 19.1%).

Table 3 shows field differences (statistically significant in each case).[33] Seminars appear most fruitful to the two life sciences, possibly suggesting that cross-fertilization of technique is most valuable therein. Graduate student interchange is deemed more helpful in the three physical sciences by a considerable margin, as is interchange with other professionals. The PhD student in the social sciences and engineering would thus appear to be somewhat more isolated, to draw less on the environmental richness (possibly therefore to be less affected by institutional wherewithal as tapped by indicators such as Roose-Andersen ratings). The utility of technicians and non-professionals shows two field values of possible interest. Sociology seems quite high; we are unclear on who provides this aid. Electrical engineering, on the other hand, seems low.

Granted that engineers have a theoretical and applied orientation, one might wonder whether PhD students with an empirical orientation could benefit from technician assistance seemingly more available, for instance, to physicists. This might (or might not) be a signal of a shortage in graduate training and research support for engineering vs. the sciences. Such an interpretation would be consistent with the poorer level of their doctoral research facilities reported by our electrical engineers, particularly vis-à-vis their present facilities tending to be quite good relative to other fields (Table 3). Indeed, two stand-in measures for current employment sector[34] both indicate significantly poorer research facilities for academics than for others, and many of the electrical engineering PhDs work in industry. Detailed breakdowns support this pattern: electrical engineers in industry report excellent current research facilities (mean =

4.3) compared to 3.1 for electrical engineers in academia and six-field averages of 4.0 for those in industry and 3.4 for academics. Within academia, there are notable differences in facilities between those actively engaged in research (4.0) and those not (2.5), suggesting that facility limitations could contribute to reduced research activity. Overall, the decrement in the level of research facilities from graduate school to current job environment is notable. This would suggest that, in general, our PhD students are receiving research training at fine facilities. In sum, while academic research facilities tend to be less adequate than other current work locales, doctoral research facilities tend to be superior to current ones.

Evaluation Criteria

The criteria for evaluation of dissertations have a shadowy character, emerging from tradition without consensual review or rejuvenation. We specifically inquired how important five criteria were in the evaluation of our respondents' dissertations. Results were as follows:

1) Explicit demonstration of competence to do research in the field ($\bar{X}$ = 4.21; 82.6% "important," responding 4 or 5 on a scale from 1 = not important to 5 = very important)
2) Originality ($\bar{X}$ = 3.74; 63.4%)
3) Significant contribution to scientific knowledge ($\bar{X}$ = 3.54; 53.7%)
4) Positive (rather than negative) findings ($\bar{X}$ = 3.19; 44.6%)
5) Relevance to practical applications ($\bar{X}$ = 2.60; 27.4%).

The first factor obtains generally. More interesting are differences in weighting placed on the others. As shown in Table 3, originality and significance are most critical in zoology, least in the social sciences. One biochemist exemplified the potential for trouble in this seemingly benign requirement:

> I worked for four years on a dissertation project which was ultimately rejected because it was "scooped." I then changed directors and projects, completing the new dissertation work in 2½ years. . . . I would strongly suggest that safeguards against such incredible waste and humiliation be incorporated into PhD programs.

Originality also tends (though not statistically significantly) to be weighed more as departmental prestige is higher. Obtaining positive findings shows strong discrepancies with biochemistry rating it most highly ($\bar{X}$ = 3.72) and psychology ($\bar{X}$ = 2.92) and sociology ($\bar{X}$ = 2.55) generally as not so crucial. Practical relevance (not shown) displays field differences similar to the basic vs. applied dimension with the engineers considering it quite important (more so than significance or positive findings, on average) and the natural sciences (physics, zoology, biochemistry) almost ignoring it. (Relevance also shows a significant demarcation according to Roose-Andersen ratings with the low rated (less than 2.00) and high rated (over 4.00) schools weighing it more heavily.) The norms for evaluating dissertations do not hold closely across the sciences, and they even fall well short of consensus within fields. We can empathize with the sociologist who noted: "I assume you mean my final dissertation - my first two were rejected."

VALUE OF THE DISSERTATION

Hypotheses

This research focused on the worth of the dissertation, emphasizing two dimensions - research value and training value. Building on the results of the earlier study of psychologists,[35] we postulated that the research value of the dissertation itself would be supported. However, based on that study and a general critical sentiment in the literature, we were less sanguine about its efficacy as a general training device. Specifically, we hypothesized that the dissertation would be weighed as

1) most valuable training by those who went on to pursue academic, research-oriented careers;

2) valuable training by those engaged in non-academic, research-oriented careers, but

3) not sufficiently valuable training to warrant the resources expended by those in non-research-oriented work.

The 1963-64 psychology PhDs assessed the dissertation as a generally positive personal experience, but one with only modest training efficacy. Those not engaged in research at the time of the questionnaire (a decade post-PhD) offered some support for alternative doctoral program strategies that tend to downplay the dissertation. We now turn to the present evidence.

Measures

Construction of suitable indicators required considerable care. In general, our orientation was to first gauge the relative levels of support for the dissertation along the dimensions just noted, then to see to what extent these could be predicted by models incorporating a number of potential influences. Concerning the research merits of the dissertation, our basic contrast replicates that of the Porter-Wolfle study of psychologists,[35] namely, to compare the rate of citation to dissertation-derived publications with that to other publications of the same authors. Publications, per se, are also tallied. The remaining measures of dissertation merit (research, training, and affect) are derived from questionnaire items (see Appendix C for derivation):

- general dissertation value ("evaluate your dissertation experience . . . as a generally valuable experience")
- training value (an index composed of four items equally weighted on raw scale scores[36] - dissertation evaluated in terms of learning to do independent research, specific research skills, writing for publication, and other professional (non-research) skills)
- research value (in addition to publication/citation measures, an index composed of three equally weighted items[36] - 1) evaluated dissertation as yielding valuable research findings; 2) satisfaction with choice of topic; and 3) inclination to pursue the research, as the greater of an item indicating actually carrying forward the research and one of a preference to do so had there been support).

<u>Research Value of the Dissertation</u>

Results with respect to the scientific research value of the dissertation are striking. One vocal opinion holds that few dissertations ever reach the light of public scrutiny. Not so - on average one sees roughly one publication directly from the dissertation (0.95/person); one, from continuation of that research (0.79/person) (see Table 5). So, dissertations do lead directly to publications besides the dissertation document per se. The distribution of publications/individual is skewed; note, for instance, that the 0.79 publications from continuation reflect the work of only about one-quarter of the sample (26.3%). Or, combining counts of publications resulting "directly from" with those resulting from

Field	N[a] Respondents	1. Pre-Dissertation Research P/Person	(% Publishing)	2. Derived Directly From the Dissertation P/Person	(% Publishing)	3. Continuation of the Dissertation Work P/Person	(% Publishing)	4. Post-PhD Work Not Related to the Dissertation P/Person	(% Publishing)
		Publications by Category							
Physics	88	0.70	(34.1)	0.89	(60.2)	0.73	(28.4)	5.46	(62.5)
Biochemistry	110	0.49	(29.1)	1.49	(70.9)	0.97	(24.5)	9.46	(82.7)
Zoology	118	1.23	(43.2)	1.37	(61.9)	1.31	(38.1)	5.88	(69.5)
Electrical Engineering	98	0.43	(19.4)	0.70	(42.9)	0.34	(20.4)	2.41	(46.9)
Psychology	102	0.81	(45.1)	0.42	(28.4)	0.52	(16.7)	4.00	(53.9)
Sociology	77	0.46	(23.4)	0.58	(27.3)	0.73	(28.6)	3.95	(50.6)
Total	593	0.66	(33.1)	0.95	(49.9)	0.79	(26.3)	5.33	(62.1)

	Total Publications[b] (P) Mean/Person	Median/Person	(% Publishing)	Citations[(c)] by Category[c]: 1. Pre-Dissertation Research C/P	(% Cited)	2. Derived Directly from the Dissertation C/P	(% Cited)	3. Continuation of the Dissertation Work C/P	(% Cited)	4. Post-PhD Work Not Related to the Dissertation C/P	(% Cited)
Physics	7.76	4.81	(85.6)	5.21	(43.5)	6.56	(48.7)	2.98	(42.2)	2.07	(30.1)
Biochemistry	12.34	10.33	(92.4)	6.17	(53.7)	7.88	(51.2)	6.87	(36.4)	3.64	(31.6)
Zoology	9.72	8.14	(82.1)	1.34	(23.4)	2.06	(40.7)	1.37	(29.7)	1.35	(25.5)
Electrical Engineering	5.07	2.28	(64.2)	1.17	(21.4)	1.26	(30.4)	0.21	(9.1)	0.58	(19.1)
Psychology	6.15	2.60	(65.4)	2.45	(41.0)	5.23	(72.1)	2.49	(49.1)	2.44	(38.2)
Sociology	7.18	4.25	(63.4)	1.43	(37.1)	3.04	(57.8)	1.93	(41.1)	0.79	(29.9)
Total	8.19	5.03	(76.1)	2.74	(34.7)	4.66	(47.4)	2.96	(35.0)	2.24	(29.8)

Note: P = journal articles, books, book chapters, and proceedings only. The total P = 4687 is reduced from the grand publication total of 6224 to 5280 by this restriction. It is further reduced to 4687 because not all publications have category identified. Comparable publication counts for the 1963-64 psychologists by category are (N = 110): 131, 71, 146, and 613.

[a] Includes those respondents indicating category for the majority of their publications (for all publications of most respondents; we picked up a few additional publications for some later in citation searching).

[b] Includes journal articles, books, book chapters, and proceedings for all categories and where category is unknown. Ns for this compilation are the total number of respondents (e.g., 645, not 593, for total).

[c] Tally is for journal articles, books, book chapters, and proceedings cited only, excluding persons for whom category is unknown for a majority of their publications to give a representative comparison (tallies will differ a bit from other tabulations). % cited gives % of P that is cited 1 or more times.

"continuation of" the dissertation shows 44.0% not publishing at all in either category; 18.7% publishing a single piece, 13.7%, two pieces; and 23.1%, three or greater (to a maximum of 16). Field differences are substantial: a majority publish from their dissertations in biochemistry - 73.6%, zoology - 71.2%, and physics - 65.9%; a minority, in psychology - 32.4%, sociology - 39.0%, and electrical engineering - 46.9%.[37] Overall, half of our sample (49.9%) did publish directly from their dissertation. This is considerably higher than previous estimates of 15% of American dissertations appearing as articles with 1% as books.[38]

Field differences are interesting. The general pattern of publication rates follows the total publication rate by field (see Table 5) with biochemists and zoologists most productive. Electrical engineers and zoologists tend to publish relatively more from their dissertations than one might have anticipated from the ten-year field averages. Zoologists and sociologists seemed relatively more apt to continue with their dissertation research post-PhD. This impression is supported by responses to questionnaire items as to whether they had carried forward their dissertation work after the doctorate and, if not, whether they would have preferred to had there been support to do so. On both items, zoologists and sociologists dominated all other fields (1 = not at all; 5 = very much; medians): carried on - zoology = 2.46; sociology = 2.55; all 6 fields combined = 2.05; if not, preferred to have - zoology = 2.36; sociology = 2.18; all 6 fields combined = 1.78.

The zoologists and sociologists rank as the most academically oriented fields, suggesting that academicians are more apt to pursue their dissertation research. Table 6 conveys that this is indeed the case: academics develop more publications from their dissertations and the continuation

Table 6. Dissertation Publication Distinctions

Comparison	N	Publications/Person Derived Directly from the Dissertation: Mean	F	Publications/Person from Continuation of the Dissertation Research: Mean	F
Non-Academic	155	0.60	4.47*	0.31	4.93*
Academic[a]	305	1.10		1.05	
Non-Researcher	241	0.44	34.07***	0.31	20.69***
Researcher[b]	236	1.45		1.32	
Quality of Graduate Faculty at PhD Institution:[c]					
0.00-1.99	85	0.58	3.58*	0.78	1.59
2.00-2.99	193	0.88		0.59	
3.00-3.99	211	1.10		0.81	
4.00-4.99	68	1.08		1.13	

Note: Conventional Analysis of Variance (ANOVA) conducted using SPSS with field as the other main effect (always significant). Means shown are not adjusted for field; such adjustment yields only small changes. Interaction between field and the main effects shown is significant only for non-researcher/researcher and direct publications ($p = .03$), though nearly so for their continuation publications as well ($p = .07$).

*$p < .05$

***$p < .001$

[a]Non-academic taken as those who have spent 10% or less of their full time equivalent (FTE) employment since the PhD in academia; academic, 90% or more.

[b]Non-researcher taken as those spending 10% or less of their time at work in 1979 on research; researcher, 33% or more.

[c]Roose-Andersen ratings (see Note 20) where the faculty raters could indicate: distinguished (5), strong (4), good (3), adequate (2), marginal (1), or not sufficient for doctoral training (0).

thereof. Not surprisingly, so do those who pursue research-oriented careers. Quality of one's graduate training faculty also associates with increasing publication from the dissertation, though not significantly so for continuation of that research.

Dissertation-derived publications can be compared to other publications by the same PhDs to get a sense of their differences on several key dimensions. Foremost is the question of how these stack up in terms of perceived quality. If the dissertation is merely a lame research exercise, publications derived should lag others produced by these PhDs in terms of citation frequency. If the research involved has merit, it should reflect in citations. To compare citations, one may adjust the measure to account for uneven time intervals available for citation; we employ a yearly rate for this.[39] We also take logarithms of the citations to reduce the weight accorded very high citation rates (to make the measure more nearly linear and suitable for general linear model statistical analyses). Table 5 displays raw citation counts that indicate substantial differences by field and category. Analyses of variance confirm the differences as significant, with biochemistry the leader in citations/publication, as also in publications/person; followed by physics, then psychology; with zoology and sociology trailing by fair margins, and electrical engineering far behind.[40] Category 2, publications directly derived from the dissertation, leads all others on each of the citation measures (significant differences among categories on all but yearly citations, controlling for field differences).[41] In particular, the log of yearly citations, controlling for field, shows a significant difference among categories [$\underline{F} = 4.86$; $p < .002$]:

1) pre-dissertation = .08 mean log citations/publication/year (N=421)
2) directly from dissertation = .13 (N=561)

3) continuation of the dissertation = .11 (N=468)

4) post-PhD, not dissertation related = .11. (N=3164)

Comparisons by field on this measure between categories 2 and 4 find category 2 more cited in every case (though essentially equal for zoology and significant only for physics and sociology); the all-fields-combined T-test is significant (p = .003). Simply, dissertation-derived publications appear to be slightly more cited than other work by the same authors.[42]

Two other differences among publications by category are notable. First, dissertation-derived publications are significantly more apt to be single-authored than other publications (ANOVA controlling for field, F = 41.32, p < .001): with 1 = single-authored and 2 = multiple-authored, categories 2 and 3 means = 1.64; category 1 = 1.70; category 4 = 1.82). This seems counter-intuitive to the notion of close guidance and collaboration with PhD supervisors. It suggests that dissertations may indeed involve less collaboration than other research enterprises. Second, the reported scale of effort invested per dissertation-derived publication exceeds that for the other categories (on a scale of 1 = <2 months full-time effort - FTE - by all authors together; 2 = 2-6 mos. FTE; and 3 = >6 mos. FTE; ANOVA controlling for field, F = 32.49, p < .001):

1) pre-dissertation publications = 2.20 (N=405)

2) directly from dissertation = 2.62 (N=576)

3) continuation of the dissertation = 2.29 (N=469)

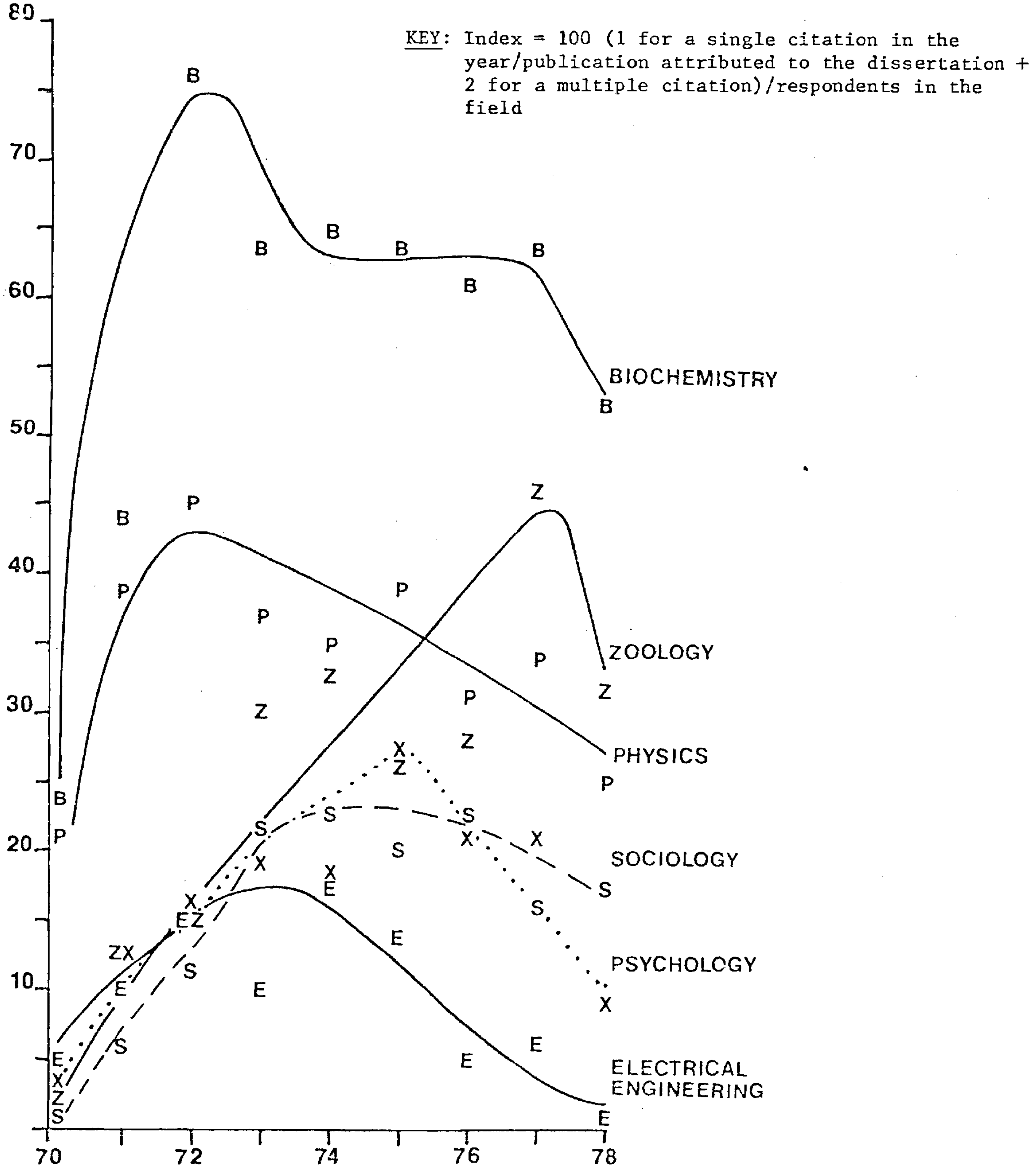
4) post-PhD, not dissertation related = 2.35 (N=3107).

So, the category 2 research publications achieve more recognition, but they also seem to evidence more work. Were one to use another indicator of effort, FTE on the dissertation (on an individual PhD rather than single publication level of analysis), the inter-field differences in publications from the dissertation greatly diminish:

physics	0.82	publication directly derived from, or from continuation of the dissertation/ FTE (years) on dissertation
biochemistry	1.24	
zoology	1.60	
electrical engineering	1.01	
psychology	1.19	
sociology	1.28.	

Figure 1 presents a constructed citation index that shows the time profile of citations to the dissertation by field. [The index counts 1 for a publication derived from the dissertation cited once in a year; it counts 2 for one cited multiple times in a year. This gives extra weight to multiple citations while damping the effect of very highly cited pieces (e.g., one biochemistry paper in this set cited 81 times in one year). The intent is to gauge the breadth of peer recognition accorded to dissertation research.] While little confidence should be placed in the exact time profiles (using other indices such as total citations or percent of publications cited results in some shifting), the patterns are suggestive. There are strong differences in the level of citation of dissertation research/person with biochemistry about twice the level of physics and zoology, three times greater than the two social sciences, with electrical engineering lower still. Zoologists publish almost as much from their dissertations directly as do biochemists (and more from continuation), but they are cited much less, and their peak is later in time. One might surmise that biochemistry and physics reflect fast-cumulating "frontier" sciences where time is of the essence to the researcher. Yet while the citations peak early in these "hard" sciences, they do not drop off sharply - in contrast to psychology and electrical engineering especially. By 1978, eight or nine years post-

FIGURE 1. DISSERTATION CITATION INDEX



PhD, all fields' dissertations show a drop in publications being cited. That is certainly consistent with the generally observed decline in citation frequency - relatively few publications are cited (the mode is zero) but a few remain prominent. By 1978 16% of dissertation-derived publications were being cited (99 of 615; range of 14-22% except for electrical engineering at 1%) down only moderately from a peak of 22% (133) cited in 1975.

As a final commentary on the research value of the dissertation, let's return to the respondents' own assessments. First, it is cautionary to note:

- a wide range of responses regarding how valuable the research findings were (1 = not satisfactory to 5 = very satisfactory) - a moderate overall median of 3.35 (40 1's, 109 2's, 203 3's, 192 4's, 98 5's; mean = 3.31), with lows of 3.10 in electrical engineering and 3.11 in psychology and a high of 3.62 in zoology
- general inclination <u>not</u> to carry forward the dissertation work after completion of the doctorate - overall median = 2.05 (mean = 2.35); however, a substantial minority do (137 of 641 indicated substantial continuation - 4 or 5 on the scale from 1 = not at all to 5 = very much), with zoologists and sociologists most apt to continue (medians of 2.46 and 2.55)
- lack of support for continuation was not denoted as a major factor - median 1.78 as preference to continue had there been support.

Poor choice of topic does not seem to be seen as the problem. The majority expressed satisfaction with their choice - median 3.87 (only 103 of 641 responded 1 or 2 on a scale from 1 = not satisfied to 5 = very satisfied). Interestingly, biochemists were least satisfied - median 3.55; zoologists (4.35) and sociologists (4.06) were most satisfied.

Turning to the composite research value index (see Appendix C), results suggest:

- overall moderate impressions of the research value (mean 3.35 on a 1-5 basis), with zoology (3.73) and sociology (3.52) leading, and biochemistry (3.10) and psychology (3.14) lagging [ANOVA indicates significant field differences, $p = .001$]
- academics associate with higher perceived research value of their dissertations [ANOVA with field as the other main effect - classical analysis - $p = .008$], as do researchers even more strongly [$p = .001$]; one might wonder whether fruitful dissertations spur students on into research careers, or whether present academicians and researchers simply put more into their dissertations (or, just impute a halo to them) - more on such modeling possibilities later
- quality rating of the graduate faculty does not relate.

In sum, one should neither over- nor underestimate the research value of the dissertation. It constitutes the first step in a scientific career, not the peak. PhD's do not generally fail to follow up because of a lack of resources (as was possibly implied by Porter and Wolfle, 1975), rather they generally seem ready to move on to other research - or non-research - interests after attaining the doctorate. Conversely, the dissertation is far more than a mundane task to be completed. It results in publications in some half of the cases (on average, yielding one direct publication/

dissertation), and those publications accrue more citations than others of the same authors.

The Dissertation - in Broader Terms

As set forth earlier, we have interests in assessing the dissertation in other than research yield terms - especially, general worth and training value. To set the context, we have three items that pertain more broadly to the graduate schooling experience. Expressed as satisfaction (on 1 = not satisfied to 5 = very satisfied scales), these show highly favorable opinions with:

- having earned a PhD - median 4.82, mean 4.60 (only 19 of 643 respondents below 3)
- graduate field of study - median 4.51, mean 4.21 (only 46 of 642 below 3)
- specialty area - median 4.23, mean 4.00 (only 69 of 643 below 3).

The pattern of support holds for each of our fields, with zoology highest on all three measures (medians of 4.88, 4.67, and 4.60, respectively) and physics lowest (medians of 4.69, 4.15, and 3.86, respectively). In sum, there are few regrets about taking the PhD as they did.

General affect toward the dissertation is also highly positive - median of 4.32, mean 4.14 (standard deviation 0.94), with only 33 of 641 below 3. Field differences are significant (ANOVA, p = .016) with zoology again pronounced (mean 4.47), with psychology trailing (mean 3.80); sociology is slightly below the overall average (mean 4.06), in contrast to its relatively favorable research value placed on the dissertation. Conversely, biochemistry is more favorably disposed on this measure (mean 4.23). One should beware of making too much of such differences. Academic (p = .082) and research (p = .019) careers associate with higher valuations placed on their own dissertations; Roose-Anderson rating does not. Again, we must note that some individuals differ dramatically. As one sociologist summarized:

> I was so burnt out and depressed I didn't want to see myself in another "class" situation. . . . My whole doctoral experience was a trauma which took me over 7 years to recover from. I still do not think I was guided into competence and skill. . . . It was a lonely battle rather than an exciting adventure.

Conversely, a physicist mentioned: "It was a very enjoyable, worthwhile, humbling, rememberable experience."

The perceived learning gained from the dissertation shows a similar profile, with some alterations. Field is still significant (p = .016) but the variation is less pronounced, ranging from physics (mean 3.66) and psychology (3.67) to zoology (3.99); overall mean 3.80. Academicians lean toward a more positive stance, but not significantly so; researchers feel they learned more than non-researchers (p = .001).

Stepping back to reflect, the dissertation valuations across research, training, and general affect measures differ in magnitude but are similar in profile. Researchers and academicians perceive the dissertation experience more favorably. A typical profile appears for the general value placed on the dissertation ("affect") according to current (1979) primary work activity:

- Researchers (and development/design specialists) - mean 4.22
- Teachers - 4.21
- Professional service persons/administrators - 3.92.

ANOVA shows the differences to be significant (p = .005), but it is more notable how favorably all of the groups reflect on their dissertations (1-5 scale from not satisfactory to very satisfactory). Those considering their main work to be teaching are most favorably inclined in each of our six fields, with sociology the exception (but there too one is more taken with the support than with the differences - means, respectively, of 4.30, 3.88, and 4.05).

By field, zoologists are most supportive with sociologists right behind in terms of research valuation, though not on training/affect indices. Biochemists, somewhat surprisingly, come down more harshly on the research value of the dissertation (while being second only to zoologists in gauging its training and affect worth). This is despite the fact that they produce the most papers directly from it (Table 5), and, even as a percentage of decade career publications, are rather high (Table 7). Yet, they show relatively less inclination to pursue the dissertation research post-doctorate by both self-report and publication tallies. As speculation, one might look toward the strong tendency of biochemists to take "post-doc's" (72.3% - more than any others, see Table 1), especially for research experience (66% of those denoting reason). This may reflect the tendency for biomedical research to demand multiple skills, implying a need for broadening oneself beyond what is learned in the dissertation experience.[43]

Psychology seems to generate the least publication (though not citation) activity from the dissertation (Tables 5 and 7), and it reflects most harshly on the research, training, and affect payoffs therefrom. This suggested to us that it might be useful to seek differential explanations. Indeed, our hypotheses postulate just such possibilities.

We looked at the research, training, and affect value placed on the dissertation by respondents and at the logarithms of publications and citations accrued, in terms of three distinctions in type of dissertation and one in subfield category. (Table 8 also displays the individual vs. collaborative distinction, but the dominance of the former made statistical

Table 7. Dissertation Publications Vis-à-Vis Early Career (First Decade) Publications

Field	Direct Dissertation Publications as % of Publications to 1979	Direct and Continuation of Dissertation Publications as % of Publications to 1979
Physics	11.5	20.9
Biochemistry	12.1	19.9
Zoology	14.1	27.6
Electrical Engineering	13.8	20.5
Psychology	6.8	15.3
Sociology	8.1	18.2
Total	11.6	21.2

Note: Table 5 presents underlying data.

Table 8. Types of Dissertations (Percent)

Field	Theoretical vs.	Empirical/ Experimental	Laboratory vs.	Field	Basic vs.	Applied	Individual vs.	Collaborative
Physics	18.8	68.8	81.3	13.3	83.5	8.2	71.9	16.7
Biochemistry	5.9	72.9	83.6	9.5	82.1	8.5	76.9	7.7
Zoology	8.3	66.1	41.8	32.0	73.0	14.8	84.3	6.6
Electrical Engineering	47.6	29.5	67.2	11.9	26.9	47.1	87.3	5.9
Psychology	13.1	49.5	62.3	27.4	57.9	30.8	87.7	7.5
Sociology	9.7	43.0	15.7	72.3	42.0	29.5	74.1	12.9
Total	16.9	55.6	58.5	27.6	61.9	22.7	80.7	9.3

Note: Percentages are based on combined 5-point scale responses; e.g., theoretical = 1 or 2; empirical/experimental = 4 or 5; the missing % reflects intermediate = 3 responses. Relative percentages are given to leave out entirely those who did not respond on scale to these items, e.g., "not applicable" (on average, less than 1% of the 645 respondents).

analyses fruitless.) ANOVAs were computed across all fields and separately for fields which showed the most suitable distributions (e.g., electrical engineering and physics on the theoretical/experimental dimension). T-tests were computed to contrast the extreme two categories (e.g., 1 vs. 5 on the type distinctions) and the extreme four categories (1 and 2 combined vs. 4 and 5).[44] Because field differences are so sharp and present a strong confound, results from individual field comparisons are most interpretable.

Theoretical vs. Empirical/Experimental. As shown in Table 8, most dissertations lean toward the empirical, with only electrical engineering deviating from this (an interesting deviation!). Those who responded in the staunchest theoretical category (1 on the 5-point scale) were consistently low in rating the dissertation's research (for all fields combined, mean 3.02 vs. overall mean 3.35), training (3.39 vs. 3.79), and affect (3.76 vs. 4.13) values (refer to Appendix C for derivation of the three indices). F- and T-tests were significant for all fields combined and for electrical engineering alone, but not for physics (on either F- or T-test for any of the three indices). While this pattern held also for publications directly related to the dissertation (logs, for all fields together, mean for staunch theoreticians 0.32 vs. overall mean 0.50) and citations (0.25 vs. 0.63), it was not significant for either field alone (and all fields combined comparisons are very confounded by field differences - c.f., Table 5). So, theoretical dissertations are rare - only about 1 in 6 classify as 1 or 2 on the 5-point scale - and not perceived as being quite as fruitful by the students. For this dimension especially, but also for the others, note in Table 8 that a sizable fraction see themselves right in the middle - e.g., dissertations equally theoretical and empirical.

Laboratory vs. Field. The laboratory setting dominates in some fields - physics, biochemistry, electrical engineering - less so in psychology, but field work comes forward to near-equivalence in zoology and dominance in sociology (Table 8). Dissertation valuations shows little to favor one or the other. Field studies tend to somewhat fewer publications and citations and to report learning less, but patterns are not sharp (e.g., category 4 tends to be lower than 5 on the 1-5 scale with 5 pegged as "field"), nor generally statistically significant.

Basic vs. Applied. An overwhelming majority of physicists and biochemists perceived their dissertations as basic research; the percentage seeing their dissertations as applied edges upward for zoologists to a sizable minority of psychologists and sociologists, with the engineers primarily applied (Table 8). Again being wary of all fields together comparison because of these strong differences, valuations show weak patterns and little remarkable. Results suggest applied and mixed dissertations yield a slightly more fruitful training experience but slightly less publication/citation activity than basic ones.

Individual vs. Collaborative. Individual work dominates in each field, but a small minority do report collaborating with colleagues, as in group research projects. Given an increasing thrust toward interdisciplinary research[45] - prompted both by intellectual puzzles demanding multiple skills for their solution (e.g., in the neurosciences) and by societal need pulling forth a blend of contributions in more applied arenas (e.g., energy), one might wonder if tradition too heavily favors non-collaborative dissertations.

Psychologists: Clinical vs. Experimental

One of the sharpest challenges to the dissertation requirement generates from the case where persons not inclined toward research are pressed to fulfill a research-oriented requirement to attain the doctorate. We perceived clinical psychology to be the prototype of this case. In fact, clinicians are significantly less research-oriented in terms of career aim, and % time on research in 1979 (mean 13.4% for clinicians vs. 16.0% for "non-lab" and 28.5% for "lab" specialties); however, their current research facilities are deemed essentially as good and their publications from 1973 onward are as numerous (mean 3.32 vs. 2.92 for non-lab and 3.33 for lab).

We can draw contrasts with respect to dissertations between those psychologists whose primary professional identification at the time of their first post-PhD job[46] is clinical or counseling and those in "lab" psychology (physiological, experimental) and other specialties grouped as "non-lab" (e.g., developmental, educational, industrial, psychometrics, social, general/other). Valuations show the clinicians as less fulfilled by the dissertation, though not significantly less productive in terms of publications (Table 9). It should be noted that their perceptions, though less favorable than their colleagues', are somewhat positive; the dissertation is not roundly condemned. Expressed opinions on possible modifications of dissertation practices show a significant contrast between clinical psychologists and lab psychologists only for degree of support for practicum or internship in lieu of the dissertation (means - clinical - 2.84, non-lab - 2.61, lab - 2.04 where 1 = strongly disapprove and 5 = strongly approve). Even here there is not notable support to alter the dissertation. On other evaluative/change items, psychologists would suggest a bit more emphasis on originality and relevance, a bit less on positive

Table 9. Psychologists' Differing Perceptions of Their Dissertations

Factor[a]	Statistical Significance[b]	"Lab" Specialties (experimental, physiological) (mean)	"Non-Lab" Specialties (e.g., developmental, educational, industrial, psychometrics, social, general/other) (mean)	Clinical (and Counseling) (mean)
		N = 26	N = 24	N = 47
Research Value	A = .13 T = .053p	3.47	3.29	2.99
Training Value	A = .26 T = .102p	3.91	3.71	3.54
General Affect	A = .03 T = .009s	4.35	3.58	3.70
Log[c] of Publications Derived from the Dissertation	A = .76 T = .53p	0.27	0.26	0.20
Log[c] of Citations to Publications Derived from the Dissertation	A = .38 T = .28s	0.62	0.32	0.33

[a]See Appendix A for derivation and composition.

[b]A shows the probability level for ANOVA - _F_-Test; T shows a _T_-test between Lab and Clinical psychologists. s indicates separate variance estimate used, while p indicates a pooled variance estimate used (based on homogeneity of variance estimates - SPSS ONEWAY routine used).

[c]Natural log of (publications or citations + 1).

findings. They lean against multiple short research exercises or reports, and are essentially neutral on alternative doctorates not oriented toward research.

Views on Policies

Coming back to the full sample, Table 10 tallies the respondents' views on current dissertation practice and potential changes. The dominant theme is resistance to change - leave the dissertation about as it is. Indeed a few respondents chastised us for raising these possibilities. A sociologist asked: "What would you have take the dissertation's place - 50 true-false questions?" A zoologist harped: "At this point we might as well list them in the Sears & Roebuck catalogue." The only change supported (beyond the neutral point - 3) is not significantly so - an overall tightening of standards. That is consistent with the sentiment that there is too little emphasis on originality. (The University of Michigan survey reported that practices for fostering student creativity could be improved or need revision in the opinion of about 40% of faculty, PhD alumni, and candidates.[47]) One point on which respondents would suggest an easing is on the demand for positive findings - and that, while statistically significant, is not large. Relevance to career needs is an area deserving increased emphasis, with (surprisingly?) physicists strongest on this point (though not statistically significant).[48] When it came to specific changes (the last four questions), none of the six fields was favorably inclined, with the sole, non-significant exception of psychology at 3.05 on the alternative doctoral degree issue. Psychology was most inclined toward changes in general, and, as we have just reviewed, clinical psychologists were most favorable among them - but they still lie on the negative side of neutral!

Table 10. Views on Current Practice and Possible Changes

How would you rate current dissertation practices in your PhD area?	Too Little 1 2 About Right 3 4 Too Much 5 (mean)
--emphasis on originality	2.66
--emphasis on obtaining positive (rather than negative) research results	3.38
--emphasis on relevance of the dissertation to student's career needs	2.52
What is your opinion of the following possible changes in doctoral requirements?	**Strongly Disapprove 1 2 3 4 Strongly Approve 5**
--Overall increase in standards and requirements to obtain the PhD (e.g., increased coursework, publication)	3.09
--Several small scale, original research exercises in lieu of the dissertation	2.18
--Dissertation research as at present, but several short reports, more like articles, in lieu of the written dissertation as presently required	2.66
--Extended practicum or internship activities to acquire professional skills that are not research-oriented, in lieu of the dissertation (within a PhD program)	2.15
--The option of alternative doctoral degrees (e.g., Doctor of Arts, Doctor of Engineering) not oriented toward research	2.63

Note: All means are significantly different from the neutral point (3) for the sample as a whole ($\underline{N}$ = 397 to 404 on the first set of questions as a sizable number of respondents felt unfamiliar with current practices and took an "NA" response option; $\underline{N}$ = 603 - 610 on the second set) at $\underline{p}$ < .001 (T-test), except for "overall increase in standards" ($\underline{T}$ = 1.84; $\underline{p}$ = .07).

Self-classification as to current (1979) primary work activity can be examined for differences in views on dissertation practices as a function of respondents' orientation toward research, teaching, or other professional services.[49] Given the dissertation is a research mechanism, with deep academic roots, the hypothesis is that those in professional activities will be less favorably disposed to it. (This extends, and actually sharpens, the clinical vs. experimental psychology contrast.[50]) Results show only a single significant distinction, on practicum/internship in lieu of the dissertation, with persons who emphasize professional services (mean 2.41) more supportive - though still quite negative - than teachers (2.13) and researchers (1.91). Interestingly (though not statistically significant), those in professional services are somewhat more concerned with too little originality (mean 2.51) and relevance (2.47), while seeing rather too much pressure for positive findings (3.53). They are more taken with the idea of changes, reaching up to a mean of 2.84 on alternative doctoral degrees - yet they remain <u>below</u> the neutral point on the last four questions (as well as being firm - mean 3.14 - on an increase in standards).

The general satisfaction with the dissertation is moderately surprising given that the dissertation is not generally perceived as relevant to one's work a decade later (Table 11).[51] This may simply suggest that a balanced perspective is in order. The dissertation is productive research, on average, and valuable training, but it is not a detailed specialization to which one is apt to stay wed indefinitely. Zoology provides a sharp contrast to all the other fields in that respondents find the dissertation, on average, highly relevant to their work a decade later. But, in general, one might consider careful thinking to assure that dissertation specialization

Table 11. Relevance of the Dissertation to Later Work

	First Post-PhD Job		Job a Decade Later[a]	
	Mean	Ratio of Relevant/ Irrelevant[b]	Mean	Ratio of Relevant/ Irrelevant[b]
Physics	2.92	0.80	2.25	0.31
Biochemistry	3.12	1.17	2.70	0.56
Zoology	3.42	2.07	3.24	1.47
Electrical Engineering	3.06	1.08	2.50	0.43
Psychology	2.76	0.68	2.29	0.26
Sociology	2.93	0.89	2.84	0.70
Total	3.05	1.05	2.65	0.55

[a] 1969-70 PhDs responding in Spring, 1979.

[b] Ratio of 4 or 5 responses to 1 or 2 responses on a 5-point scale from 1 = not at all to 5 = very much. 1.00 would signify as many saying relevant as irrelevant.

is not undue. The dissertation is best, on average, as a vehicle to learn how to do independent research (mean 4.29, median 4.48); teaching specific research skills relevant later trails somewhat in payoff (mean 3.74; median 3.95).

Influences on Dissertation Value

We now turn to development of simple models that can relate demographic factors and graduate training attributes to the yield of a valuable dissertation. While the previous section reflected a testing of certain hypotheses, plus simple description of our respondents, this section strives to develop plausible causal models from an empirical data base. Conceptual guidance as to what leads to a "good" dissertation experience is lacking; the previous study found little of note in that regard.[52] The reader must beware the limitations in the inductive generation of cause and effect relationships from a single data base; results here should be considered hypotheses meriting further testing.[53]

Before exploring our modeling efforts, we note one variable of some special interest not included in the modeling because of its lack of predictive utility. Given the folklore that urges prospective graduate students not to go on at the same school from which they receive their Bachelor's degrees, we took a look at this as a discriminator. Simply put, it doesn't. Of the 496 respondents for whom we have Bachelor's information (the query was poorly worded), only 79 attended the same school for their PhDs (15.9%) and, of those, 27 attended another school for a master's or second bachelor's - so only 10.5% actually went straight through (the "folk warnings" generally prevail). Using the 79 as the comparative sample, there was essentially no difference with the whole respondent sample on variables such as PhD aims, criteria for choice of graduate program (except that situational factors were more salient for those who attended the same school for the PhD and the Bachelor's - mean 4.09 vs. 3.25 on a 1-5 scale, with 5 = very important - $p < .001$ by T-test), interactions with supervisor and peers in graduate school, evaluation of the dissertation experience, and publication rates. Time from Bachelor's to PhD was shorter (mean 6.66 years vs. 7.77 - $p < .05$ by T-test), but that could well be explained in terms of fewer persons taking time out to do other things before the PhD.

Modeling was directed at accounting for research publications and citations from the dissertation, and general value ascribed to the dissertation ("affect") and learning attributed to the experience. Table 12 scans a broad array of regressions to provide a succinct overview. What emerges is an impression of modest order. Note that the amount of variance accounted for rarely reaches 50%, as indicated by the R^2 values in Table 12. Individually prominent coefficients are never replicated in all 6 fields, yet distinct patterning appears. Without overplaying distinctions or similarities, we believe interesting information is contained herein.

Table 13 plays on the conceptual and empirical clustering of dependent variables to look at publications and citations side by side, then general affect toward the dissertation along with training effectiveness. "Perceived research value" tends to follow the latter two measures generally, but several differences emerge:

- Extended time for the dissertation was a substantially negative predictor only for Sociology.
- Evaluation based on personal competence was positive only for Physics and Biochemistry.

Table 12. Influences on Dissertation Effectiveness

Dependent Variables: Log of Citations to Publications Derived Directly from the Dissertation Research

Independent Variables	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Policy-Sensitive Influences							
Began dissertation research later in graduate study							⊖
Dissertation time (calendar months)							
Dissertation time (full time equivalent months)							
Dissertation time, percent spent on:							
—problem formulation/conceptual development				+		-	
—data gathering		+			-		
—data analysis	-			-			
Extent that paid employment during the dissertation research period related to the dissertation	⊕	+					
Federal grant support instrumental to dissertation						+	
Importance in evaluation of your dissertation:							
—originality						+	+
—significance of contribution to science	⊕	⊕	+	+		+	
—positive findings					+		
—relevance to practical applications	⊖		-				-
—demonstration of your competence							+
Extent of supervision by supervisor	-						
Conflict with/among supervisor/committee							
Stimulation by supervisor							
Stimulation by committee							⊖
Co-authorship with supervisor							
Helpfulness in dissertation work/doctoral training:							
—seminars							
—graduate students				-			
—assistance from other professionals (not on committee)					-		
—assistance from technicians/non-professionals				-	+		
Adequacy of dissertation research facilities							
R^2	.16	.38	.24	.29	.30	.39	.39
Individual Choice Factors							
Importance in selection of particular PhD program:							
—department reputation							
—specialty area reputation							
—intent to work with specific faculty member		-					
Importance in choice of dissertation topic:							
—scientific importance	⊕			⊕		⊕	
—inherent interest	⊖			⊖			
—manageable study to fulfill requirements							
—faculty preference			-				
—environmental considerations (availability of assistance, facilities, etc.)	+			-	⊕		
Supervisor prominence	⊕						
N of other dissertations supervisor had guided to completion	⊖		⊖		-		
N of other dissertations supervisor guiding concurrently			⊕	+			
Rated quality of the graduate faculty (Roose-Andersen)	+					+	
R^2	.07	.12	.19	.13	.14	.26	.16

Dependent Variables: Log of Publications Derived Directly from the Dissertation Research

Independent Variables	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Policy-Sensitive Influences							
Began dissertation research later in graduate study	⊖			-			⊖
Dissertation time (calendar months)							
Dissertation time (full time equivalent months)				+			
Dissertation time, percent spent on:							
—problem formulation/conceptual development							
—data gathering				-			
—data analysis							
Extent that paid employment during the dissertation research period related to the dissertation	⊕	+					
Federal grant support instrumental to dissertation					+		
Importance in evaluation of your dissertation:							
—originality	⊕		+			+	+
—significance of contribution to science	⊕	+				+	
—positive findings	⊕						
—relevance to practical applications	⊖		-				-
—demonstration of your competence							+
Extent of supervision by supervisor	-						-
Conflict with/among supervisor/committee							
Stimulation by supervisor	-		⊖				
Stimulation by committee							-
Co-authorship with supervisor	+		⊕				
Helpfulness in dissertation work/doctoral training:							
—seminars			-	+			
—graduate students					+		
—assistance from other professionals (not on committee)					-		
—assistance from technicians/non-professionals		+			+		
Adequacy of dissertation research facilities							
R^2	.20	.34	.28	.29	.25	.34	.40
Individual Choice Factors							
Importance in selection of particular PhD program:							
—department reputation	-			-	-		
—specialty area reputation							
—intent to work with specific faculty member							
Importance in choice of dissertation topic:							
—scientific importance	⊕	+				⊕	⊕
—inherent interest	⊖	-		-			
—manageable study to fulfill requirements	⊖						
—faculty preference				⊖			
—environmental considerations (availability of assistance, facilities, etc.)	⊕	⊕			⊕		
Supervisor prominence	+						+
N of other dissertations supervisor had guided to completion	⊖			-	-		
N of other dissertations supervisor guiding concurrently					+		
Rated quality of the graduate faculty (Roose-Andersen)	⊕			+			+
R^2	.11	.20	.08	.27	.13	.34	.23

Dependent Variables: Dissertation Seen As a Generally Valuable Experience

Independent Variables	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Policy-Sensitive Influences							
Began dissertation research later in graduate study	⊖			-	-	⊖	
Dissertation time (calendar months)	-					⊖	
Dissertation time (full time equivalent months)	+						
Dissertation time, percent spent on:							
—problem formulation/conceptual development		+					
—data gathering	+					+	
—data analysis	⊕					+	
Extent that paid employment during the dissertation research period related to the dissertation					+	⊖	
Federal grant support instrumental to dissertation							
Importance in evaluation of your dissertation:							
—originality							
—significance of contribution to science	⊕			+		⊕	
—positive findings							
—relevance to practical applications	+		+				+
—demonstration of your competence	⊕		+		⊕	⊕	
Extent of supervision by supervisor					+		
Conflict with/among supervisor/committee	⊖	+				-	
Stimulation by supervisor							
Stimulation by committee					+		
Co-authorship with supervisor							
Helpfulness in dissertation work/doctoral training:							
—seminars					+		
—graduate students					+	⊖	
—assistance from other professionals (not on committee)							
—assistance from technicians/non-professionals	⊕	+					
Adequacy of dissertation research facilities	⊕	+		⊕			+
R^2	.27	.53	.41	.40	.46	.37	.40
Individual Choice Factors							
Importance in selection of particular PhD program:							
—department reputation	+		⊕				
—specialty area reputation		+				-	
—intent to work with specific faculty member	⊕					⊕	
Importance in choice of dissertation topic:							
—scientific importance	⊕				+	+	+
—inherent interest	⊕			+	+	+	⊕
—manageable study to fulfill requirements	⊖		-		-		
—faculty preference	⊕	⊕			⊕		
—environmental considerations (availability of assistance, facilities, etc.)	+						
Supervisor prominence	+			⊕			
N of other dissertations supervisor had guided to completion		+	+		⊖		
N of other dissertations supervisor guiding concurrently				+		-	
Rated quality of the graduate faculty (Roose-Andersen)	⊖		-				-
R^2	.16	.22	.27	.13	.36	.28	.31

Dependent Variables: Extent of Learning Credited to the Dissertation Experience

Independent Variables	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Policy-Sensitive Influences							
Began dissertation research later in graduate study				-			
Dissertation time (calendar months)	-	-				-	
Dissertation time (full time equivalent months)							
Dissertation time, percent spent on:							
—problem formulation/conceptual development	⊖				⊖		
—data gathering					⊖		
—data analysis							
Extent that paid employment during the dissertation research period related to the dissertation						-	
Federal grant support instrumental to dissertation	-				-	-	
Importance in evaluation of your dissertation:							
—originality	+					+	
—significance of contribution to science	⊕			⊕	-	+	
—positive findings							
—relevance to practical applications	⊕		+		+		+
—demonstration of your competence	⊕	⊕				⊕	⊕
Extent of supervision by supervisor							
Conflict with/among supervisor/committee							
Stimulation by supervisor	+						
Stimulation by committee						+	
Co-authorship with supervisor							
Helpfulness in dissertation work/doctoral training:							
—seminars	⊕				+		
—graduate students						⊖	
—assistance from other professionals (not on committee)	+	+		+			
—assistance from technicians/non-professionals	⊕		+		+		
Adequacy of dissertation research facilities	⊕			⊕			⊕
R^2	.29	.48	.35	.47	.50	.53	.43
Individual Choice Factors							
Importance in selection of particular PhD program:							
—department reputation					+		
—specialty area reputation	+	⊕					
—intent to work with specific faculty member	+		+	+		-	
Importance in choice of dissertation topic:							
—scientific importance	⊕	+				+	
—inherent interest	⊕		+	⊕		⊕	⊕
—manageable study to fulfill requirements	⊖		-				
—faculty preference	+	+			+		
—environmental considerations (availability of assistance, facilities, etc.)	+						+
Supervisor prominence				⊕	+		
N of other dissertations supervisor had guided to completion	-		+	-			
N of other dissertations supervisor guiding concurrently	⊕			⊕			
Rated quality of the graduate faculty (Roose-Andersen)					-		
R^2	.16	.34	.17	.21	.29	.31	.24

Dependent Variables: Perceived Research Value of the Dissertation

Independent Variables	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Policy-Sensitive Influences							
Began dissertation research later in graduate study							
Dissertation time (calendar months)							
Dissertation time (full time equivalent months)							
Dissertation time, percent spent on:							
—problem formulation/conceptual development	-						
—data gathering							
—data analysis							
Extent that paid employment during the dissertation research period related to the dissertation	⊖	-					
Federal grant support instrumental to dissertation		-					
Importance in evaluation of your dissertation:							
—originality	⊕						⊕
—significance of contribution to science	⊕	+	+	+	⊕	⊕	
—positive findings						⊕	
—relevance to practical applications	⊕				⊕		
—demonstration of your competence							
Extent of supervision by supervisor							
Conflict with/among supervisor/committee				-			
Stimulation by supervisor	⊕		+	⊕			
Stimulation by committee	+			+			-
Co-authorship with supervisor	-					-	
Helpfulness in dissertation work/doctoral training:							
—seminars							
—graduate students						⊖	
—assistance from other professionals (not on committee)							
—assistance from technicians/non-professionals	⊕					⊕	
Adequacy of dissertation research facilities	⊕			+			+
R^2	.34	.45	.41	.45	.54	.33	.53
Individual Choice Factors							
Importance in selection of particular PhD program:							
—department reputation	+	⊕	+		+		
—specialty area reputation					-	+	
—intent to work with specific faculty member	⊕		⊕				+
Importance in choice of dissertation topic:							
—scientific importance	⊕		⊕		⊕	⊕	⊕
—inherent interest	⊕	⊕		+	⊕	⊕	+
—manageable study to fulfill requirements	⊖					-	-
—faculty preference	-						
—environmental considerations (availability of assistance, facilities, etc.)	⊕					⊕	
Supervisor prominence	⊕			⊕	⊕	+	
N of other dissertations supervisor had guided to completion	⊖		-	-	-		⊖
N of other dissertations supervisor guiding concurrently	⊕	-	⊕		+		
Rated quality of the graduate faculty (Roose-Andersen)					-		
R^2	.35	.39	.37	.23	.30	.59	.46

Key: + indicates a positive regression coefficient; -, a negative one. Circled values are significant at $p < .05$ (F to enter/remove); uncircled values have $p < .20$. Fields are physics, biochemistry, zoology, electrical engineering, psychology, and sociology.

Note: Regressions run separately for each dependent variable, for each field and for all fields taken together, for each of the two sets of independent variables. Regressions are multiple, with pairwise deletion of missing value cases (stepwise results quite similar in 36 trial comparisons; likewise for listwise deletion except that the N was seriously reduced in many regressions). See the original questionnaire (Appendix A) for full description of the independent variables; see Appendix C for elaboration on the dependent measures. Note that many are ordinally scaled.

[a] The composite stimulation index is the greater of the supervisor and committee stimulation responses; it correlates highly (r = .87 for all fields together) with supervisor stimulation. This collinearity accounts for the complementary regression coefficients seen in prediction of publications and perceived research value.

[b] Co-authorship was excluded from the regressions on publications and citations because of the inherent confounding. In preliminary runs it was the strongest predictor of all field (and physics, but not psychology) publications.

Table 13. Strongest Influences on Dissertation Effectiveness

Policy-Sensitive Influences

A. On Research Output

	(Log) Publications Derived Directly from the Dissertation Research							(Log) Citations to Publications Derived Directly from the Dissertation Research						
	All Fields	Phy	Bio	Zoo	EE	Psy	Soc	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Importance in evaluation of your dissertation:														
—originality	102 (209)	-121 (-041)	289 (591)	114 (309)	071 (126)	193 (282)	203 (189)	045 (150)	-149 (045)	142 (175)	-005 (148)	175 (179)	179 (293)	244 (134)
—significance of contribution to science	139 (330)	273 (257)	396 (530)	216 (385)	120 (143)	194 (337)	100 (199)	187 (242)	414 (505)	381 (250)	215 (257)	062 (232)	188 (337)	003 (099)
—positive findings	084 (178)	-036 (-096)	032 (110)	077 (084)	227 (153)	244 (207)	178 (106)	029 (102)	-094 (-114)	-196 (-043)	044 (092)	205 (360)	134 (188)	150 (041)
—relevance to practical applications	-181 (-207)	-031 (-055)	-257 (-142)	-146 (-247)	034 (066)	-232 (-117	-275 (-245)	-189 (-190)	042 (-020)	-242 (-350)	-134 (-219)	-004 (018)	-184 (-103)	-253 (-219)
Extent that paid employment during the dissertation research period related to the dissertation	187 (176)	208 (317)	099 (005)	119 (086)	-148 (071)	051 (259)	-050 (-074)	150 (187)	244 (241)	-011 (055)	050 (106)	-093 (073)	108 (238)	-023 (010)
Began dissertation research later in graduate study	-112 (-229)	-215 (011)	-098 (-129)	-137 (-104)	-013 (-045)	018 (-100	-360 (-178)	034 (-092)	-003 (132)	019 (034)	-037 (-025)	058 (059)	112 (-010)	-384 (-204)

B. On Affect and Learning

	Dissertation Seen as a Generally Valuable Experience							Extent of Learning Credited to the Dissertation Experience						
	All Fields	Phy	Bio	Zoo	EE	Psy	Soc	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Importance in evaluation of your dissertation:														
—significance of contribution to science	153 (294)	-135 (-025)	003 (310)	184 (352)	139 (303)	356 (421)	130 (340)	128 (267)	023 (128)	052 (228)	248 (366)	-207 (152)	224 (298)	090 (304)
—relevance to practical applications	072 (017)	-064 (-016)	182 (328)	-102 (-141)	034 (177)	091 (012)	228 (298)	131 (128)	049 (122)	182 (199)	075 (-012)	229 (318)	095 (132)	151 (244)
—demonstration of your competence	140 (175)	134 (275)	213 (217)	060 (150)	302 (214)	259 (231)	090 (098)	148 (214)	305 (365)	174 (134)	095 (363)	115 (-012)	289 (371)	238 (289)
Helpfulness in dissertation work/doctoral training: —assistance from technicians/non-professionals	100 (159)	210 (357)	142 (177)	-035 (020)	009 (255)	230 (083)	082 (183)	100 (224)	163 (399)	219 (287)	-052 (134)	112 (300)	183 (151)	037 (128)
Adequacy of dissertation research facilities	127 (248)	222 (385)	009 (238)	338 (580)	125 (235)	-150 (048)	285 (345)	186 (305)	152 (346)	-000 (171)	320 (433)	131 (175)	100 (143)	438 (460)
Began dissertation research later in graduate study	-138 (-218)	-113 (-131)	073 (040)	-171 (-279)	-168 (-299)	-264 (-215	001 (-009)	-031 (-128)	-125 (-097)	001 (009)	-374 (-308)	071 (-040)	-125 (-023)	-003 (-030)
Helpfulness in dissertation work/doctoral training: —seminars	048 (180)	103 (177)	028 (176)	048 (279)	212 (340)	040 (-040	-019 (132)	097 (212)	042 (141)	114 (171)	092 (270)	193 (343)	135 (137)	037 (172)
Dissertation time (calendar months)	-023 (-015)	-279 (-223)	-127 (-123)	-034 (138)	074 (185)	-344 (-304	-114 (-110)	-077 (-076)	-332 (-149)	-003 (-146)	-128 (034)	038 (352)	-205 (-350)	052 (-109)

Individual Choice Factors

C. On Research Output

	Publications Derived Directly from the Dissertation Research							Citations to Publications Derived Directly from the Dissertation Research						
	All Fields	Phy	Bio	Zoo	EE	Psy	Soc	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Importance in choice of dissertation topic:														
—scientific importance	138 (165)	218 (175)	-043 (019)	075 (134)	-077 (039)	294 (371)	375 (349)	171 (115)	164 (117)	-018 (060)	255 (311)	053 (144)	340 (350)	317 (172)
—inherent interest	-103 (-041)	-187 (-157)	-085 (-031)	-141 (-105)	044 (050)	-097 (-037)	134 (148)	-113 (-076)	001 (-013)	-140 (-034)	-250 (-260)	058 (044)	-114 (-086)	101 (107)
—environmental considerations	096 (060)	278 (193)	-019 (-052)	-055 (-252)	380 (239)	148 (205)	044 (079)	070 (071)	045 (040)	-010 (063)	-194 (-246)	269 (276)	138 (237)	135 (134)
Supervisor prominence	094 (120)	-039 (019)	241 (137)	083 (129)	053 (035)	198 (281)	-020 (-017)	100 (103)	044 (113)	071 (157)	059 (096)	-007 (-035)	135 (260)	037 (-028)
# of other dissertations supervisor had guided to completion	-122 (-080)	030 (017)	043 (080)	-173 (-113)	-196 (-037)	-067 (077)	-140 (-194)	-074 (-049)	131 (111)	-333 (-021)	-048 (-031)	-760 (-147)	029 (064)	-251 (-230)
Rated quality of the 138 graduate faculty	138 (130)	034 (097)	089 (148)	164 (182)	064 (062)	052 (159)	213 (187)	092 (119)	-049 (093)	108 (078)	122 (351)	023 (063)	170 (203)	120 (101)

D. On Affect and Learning

	Dissertations Seen as a Generally Valuable Experience							Extent of Learning Credited to the Dissertation Experience						
	All Fields	Phy	Bio	Zoo	EE	Psy	Soc	All Fields	Phy	Bio	Zoo	EE	Psy	Soc
Importance in selection of particular PhD program:														
—department reputation	097 (135)	-041 (057)	432 (396)	089 (102)	170 (242)	175 (-027)	032 (074)	061 (165)	134 (195)	139 (203)	057 (133)	241 (344)	112 (086)	091 (137)
—specialty area reputation	031 (151)	216 (370)	-027 (245)	128 (155)	-047 (175)	-227 (032)	-097 (071)	134 (262)	270 (397)	034 (213)	142 (706)	149 (388)	002 (188)	053 (140)
—particular faculty member	117 (224)	335 (217)	031 (121)	-114 (106)	-034 (157)	279 (326)	040 (049)	083 (234)	304 (336)	068 (180)	-156 (081)	039 (165)	153 (248)	114 (134)
Importance in choice of dissertation topic:														
—scientific importance	155 (239)	065 (034)	118 (234)	031 (120)	232 (393)	281 (282)	221 (315)	144 (242)	302 (197)	202 (251)	012 (140)	157 (298)	278 (299)	134 (242)
—inherent interest	351 (243)	106 (160)	083 (187)	143 (194)	169 (257)	394 (204)	372 (422)	124 (217)	-140 (014)	017 (127)	242 (236)	-083 (056)	352 (393)	300 (336)
—manageable study to fulfill requirements	-540 (-389)	004 (-050)	-166 (-115)	-082 (-144)	-136 (-273)	-074 (-259)	-087 (-194)	-084 (-127)	-120 (-101)	-146 (-093)	055 (-043)	-839 (-084)	-088 (-314)	-063 (-136)
—faculty preference	094 (031)	277 (280)	100 (109)	034 (-033)	296 (185)	-071 (-072)	-003 (-141)	079 (032)	175 (390)	002 (002)	022 (-057)	140 (167)	097 (042)	104 (001)
—environmental considerations	056 (027)	033 (086)	015 (-004)	-034 (-077)	074 (327)	227 (068)	070 (-081)	082 (060)	127 (143)	130 (069)	-041 (-100)	128 (213)	047 (027)	118 (046)
Supervisor prominence	065 (128)	-103 (068)	088 (-191)	241 (255)	112 (028)	-054 (-035)	169 (174)	059 (142)	-066 (048)	030 (179)	252 (282)	165 (163)	-003 (050)	003 (071)
# of other dissertations supervisor had guided to completion	-060 (-016)	156 (190)	191 (313)	-088 (022)	-304 (-268)	-029 (-121)	-003 (163)	-083 (010)	-008 (024)	244 (201)	-183 (-074)	-109 (-322)	-172 (-142)	-184 (033)
Rated quality of the graduate faculty	-092 (-059)	085 (023)	-353 (032)	-119 (023)	-119 (-104)	-132 (-223)	-252 (-170)	-052 (-009)	-028 (-033)	009 (007)	032 (151)	-188 (-010)	-119 (-188)	-119 (-029)

Note: See Table 12 for indication of which coefficients are statistically significant and for cautions in interpretation. Decimal point understood for each coefficient (107 represents 0.107). Coefficients are standardized regression coefficients - β - and, in parentheses, raw Pearson product-moment correlations (r).

- Stimulation and inspiration by the dissertation supervisor was positive overall and for every field except electrical engineering.
- Faculty preference as a factor in dissertation topic selection is a slightly negative influence.

So, the profile suggested is that one's perception of dissertation research value (as per this index, at least - Appendix C) generally tracks one's perception of the amount one learned and the general value of the experience - more than it tracks publication and citation rates.[54] Perceived research value seems strongly linked to supervisor stimulation, whereas other dissertation valuations are not. Conversely, supervisor say in choice of topic seems to reflect well on training and general valuation, but not on research valuation nor on derived publications/citations. There may be a clue here linking student initiative with research effectiveness, but faculty guidance linking with a sense of being well cared for.

Taking the potential influences that seemed subject to educational policies, one must first acknowledge that the measures examined[55] account for only a modest amount of the variance in the dependent measures, doing considerably better within fields than across, and doing better for the perceptual measures than the outputs.[56] The dominant influence set seems to be the perceived criteria underlying evaluation of one's dissertation. <u>Pressure toward scientific significance, originality, and, to a lesser degree, positive findings</u> (i.e., confirming rather than refuting hypotheses) <u>is associated with enhanced output</u>; pressure toward relevance runs counter to publications and citations being generated. In addition, the two factors of beginning the dissertation research early and receiving financial support in conjunction with that research associate with increased productivity.[57] With respect to training and general affect valuation, we see a reversal on the effect of one evaluation criterion - with relevance positive here, scientific significance as still probably the most consistent positive predictor, and competence demonstration entering as a positive force. Beginning the dissertation early relates to favorable reflections later, as it did with publications/citations. New factors appearing here that did not significantly relate to publications/citations produced are having found helpfulness (technicians and seminars), good research facilities (interestingly, did not associate with research output), and shorter elapsed time.

Individual choices that seem to have worked toward a more productive dissertation experience are now considered - but the caution must be raised that only a meager amount of variance is accounted for (Table 12). Some interesting observations can be offered:

- Selectivity in terms of departmental and specialty area reputation and particular faculty member as intended dissertation supervisor each contributes modestly to a generally valuable/effective training dissertation, but not to publication/citation output.
- Conversely, a more prestigious department (Roose-Andersen rating) associates with more dissertation publications and citations, but less satisfaction with the dissertation training and general value.[58]
- Dissertation topic selection based on scientific importance is favorable on all counts; selection based on personal interest seems positive for training/affect but negative for output (publications/citations); by faculty preference is favorable for training/affect; by manageability is a negative predictor; and by environmental

factors, favorable for output.

- Supervisor prominence helps on all counts, but, in general, one seems to do better choosing a supervisor who, all else equal, has guided fewer dissertations.[59]

An ongoing concern in our analyses is the extent to which aggregation across the science-based fields makes sense. The dissertation valuation analyses do not help resolve this key issue. On one hand, patterns seem to hold with fair regularity in Tables 12 and 13. On the other, rarely do those patterns encompass all the fields on a given independent variable across a pair of related dependent variables (Table 13), and variance accounted for (R^2) is uniformly and substantially higher within fields than across fields. Some intriguing differences are worth noting:

- The effect of dissertation evaluation criteria on physicists deviates strongly from the general pattern - e.g., pressure toward originality and positive findings leads to less publication (and citation) (possibly the norms are so strong that explicit pressure appears more for those with little research initiative).
- Paid employment related to the dissertation augered against publication (and citation) for electrical engineers and sociologists (perhaps implying that financial interests pulled them away from their inherent research inclinations; for all fields combined and for these two fields alone this variable shows a bimodal distribution with the dominant mode no such support and the second one at "very much = 5 on the 5-point scale).
- Selection of a graduate program based on a particular faculty member as prospective dissertation advisor predicted against perceived

training and general value of the dissertation (this seems to reflect different norms - most zoologists do have a particular professor in mind - median = 4.29 on a 1-5 scale, whereas most others do not - all fields median = 2.54).

- Selection of dissertation topic based on inherent personal interest is a negative predictor of scientific output except for the electrical engineers and sociologists for whom it is positive (possibly the research orientation is less pervasive here and it takes that extra interest to invest the extra effort to publish; in contrast, in other areas perhaps personal interest is apt to lead one away from mainstream - publishable - research, as a supervisor might push for).
- Zoologists seem to react counter to the other fields in response to environmental considerations prompting choice of dissertation topic; for others it is a positive predictor of all dissertation outcomes (generally); for zoologists, negative (possibly reflecting a different complex of considerations).
- Physicists seemed to react opposite to the others with respect to the effect of a prominent supervisor - they tending to be less pleased with the training and overall value, and perhaps less productive. They also run counter to the others in relating more favorably to and yielding more output from dissertations guided by advisors who have had more dissertations completed. In that biochemists show similar tendencies, this could derive from a large and active lab under the luminous professorial leader phenomenon.

The previous characterizations are based on patterns of coefficients seen in Table 13, seeking a sense of robustness in replication across the dependent variables rather than in statistical significance (there is simply not much signal present at the .05 level - see Table 12). Compilation of a tally based on the number of times that a field broke with the general pattern for the independent variables tabulated in Table 13 led to a surprising result. The field deviating most from the remainder was physics; those deviating least were the social sciences. On the constructed scale[60]:

physics = 4.8 deviation units

electrical engineering = 4.1

biochemistry = 3.8

zoology = 3.7

sociology = 2.5

psychology = 1.7.

This runs sharply counter to our expectations that engineering and sociology would be atypical. It suggests further research on the extent of deviation among science-based fields in their graduate training and professional/research approaches. To speculate, a possible driving force for the observed differences may lie in large lab science (especially physics) vs. small entrepreneur models (natural and social sciences) - with engineering differing in some other ways in its research, career, and training orientations.

Tracking Beyond the Doctorate

We examined four variables that fall after the doctorate, but do not directly relate to early career achievement as such: supervisor aid in attaining the first post-PhD job, extent to which the dissertation work is continued, post-doctoral appointment, and percent time devoted to research on current (1979) job. Some 45 variables reflecting a variety of graduate training characteristics, early publications, and so forth were examined through stepwise regressions as predictors of these four variables. In general, the variance predicted for all fields combined was greater than that for individual fields, suggesting generalization is warranted. However, individual field regressions were examined to avoid confounding field differences with variable influences (e.g., biochemists hold proportionately more post-doc's than our other fields do and they publish more from their dissertations, contributing to an overall positive regression coefficient, yet no within-field regression shows a sizable relationship between dissertation-derived publications and taking a post-doc).

Results for the individual regressions prompt an impressionistic model. Recognizing this as empirical and not refined, the regression patterns suggest something along the lines of the model illustrated in Figure 2. Three concepts seem to cluster the measured independent variables that appear prominent in the regressions and their influence appears to flow through the set of four dependent measures of concern here. The depiction and support of these runs as follows.

- Research/academic orientation appears in the guise of research-orientation as a career aim in seeking the PhD, and not professional practice as such an aim; teaching as a career aim (especially for psychologists); and several other correlates not included in the regressions per se (e.g., full time equivalent years in academia). Correlations/regression coefficients are positive with all the other variables in the model, but very weakly so with continuation of the dissertation work.
- Close relationship with supervisor encompasses stimulation by

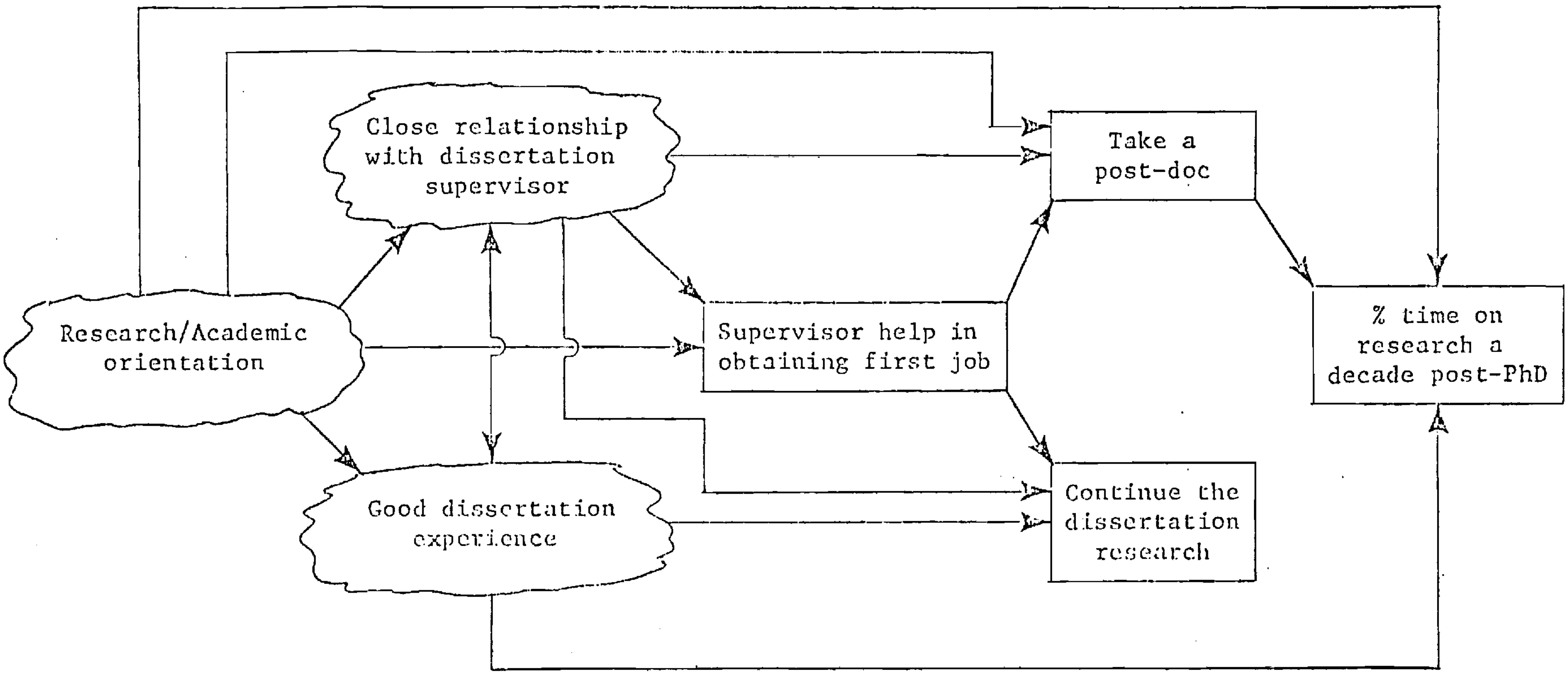


Figure 2. An Impressionistic Model of Factors Supporting a Research-Oriented Career

supervisor, co-authorship, absence of conflict, and indicators of direct financial support in doing the dissertation. It links directly to supervisor help in securing first post-PhD job, but (in various measured variable combinations) also with all the other variables short of "% time in research currently."

- Good dissertation experience seems to conceptualize the communality in measured variables including: scientific importance and not manageability as criteria in choosing topic, publications resulting from the dissertation, evaluation criteria promoting scientific significance, and favorable assessment as a learning experience. It relates as shown in Figure 2.

We hesitate to make too much of this in that it is derived post hoc and the patterns are based on somewhat subjective weighing of a large array of raw regression data. Nonetheless, a few observations are in order. The overall profile suggests that individual predispositions toward research may be importantly augmented by the dissertation experience per se and the relationship with the supervisor. These may bear importantly on career paths, suggesting they merit serious attention on the part of the PhD student and graduate education policy-makers to assure beneficial outcomes.

One non-relationship of Figure 2 merits noting. Continuing the dissertation research is only slightly related ($\underline{r}$ = .09) to taking a post-doc. This suggests that those who would encourage such continuation (c.f., Porter and Wolfle)[61] should not necessarily lean on the post-doc as a vehicle for that; however, we also note that the correlation is positive and sizable in three of our six fields: physics (.37), sociology (.25), and zoology (.20). Also, we note that while continuation of the dissertation does not appear as a direct predictor of percent time in research a decade post-PhD in any of the seven regressions (all fields together and the six individually), it is a positive correlate, ranging from a low of .13 in Physics to a high of .30 in Sociology, overall .17.

Table 14 provides details on one of the regressions for its particular interest and to illustrate more generally the sense of this exploration. Six variables meet a stringent, though empirical, statistical cut-off in estimating percent time on research a decade post-PhD across all fields. Two of these suggest a research/academic orientation (the two career aims); two reflect an effective dissertation experience (publications and relevance to current work), and one is taking a post-doc. We add that the six variables generally stand out in the corresponding within-field regressions. The amount of variance in percent time to research accounted for, given the vagaries of one's evolving career responsibilities, is quite substantial. The potential policy implications would seem to resolve around the importance of effecting a worthy dissertation experience and considering post-doctoral appointments to enrich the budding researcher.

PREDICTION OF EARLY CAREER STATURE

Orientation

Twenty years of literature on career patterns of scientists have yielded a surfeit of maxims and a modicum of methods to guide research. In reviewing this literature - a task we won't undertake here - one observes a growing sophistication of analysis that nonetheless falls prey to a recurrent set of myths. These myths portray scientists as an undifferentiated labor force of predominantly physical scientists who do research in academic settings and gain visibility and eminence as a byproduct of their pursuit of truth. Wisdom, altruism, industry, and open-mindedness are attributed to these scientists; a similar constellation of organizational

Table 14. Influences on Percent Time Devoted to Research a Decade Post-PhD

Stepwise Regression Truncated When the F statistic to enter is not significant at the .05 level[a] (R^2 = .34 with 6 variables included):

Independent Variable	β	b	F	r
Career Aim in seeking PhD: research oriented (1-5 scale with 1 = not important to 5 = very important)	.269	6.140	39.06	.415
Held a post-doctoral fellowship or temporary research associateship	.251	4.074	34.62	.395
Relevance of dissertation to current work activity (1-5 scale)	.156	3.691	13.60	.299
Publications (articles, books, chapters, proceedings) derived directly from the dissertation research	.115	2.745	7.43	.288
Field shift from dissertation to current primary professional identification[b]	-.118	-0.036	8.10	-.171
Career aim in seeking PhD: professional practice (1-5 scale)	-.119	-2.448	8.09	-.275

Note: Several of the independent variables are ordinal; results are suggestive, not definitive. All variables included are significant at the .005 level.

[a]Four other variables would enter at probabilities less than .08:
--Federal fellowship or traineeship instrumental to pursuit of doctorate (β = .063, b = 0.986, F = 2.44, r = .154)
--Rated quality of graduate program - Roose-Andersen rating (β = .090, b = 3.195, F = 4.89, r = .154)
--Estimated N of dissertations guided to completion by one's supervisor at time of own dissertation (β = -.076, b = -0.136, F = 3.53, r = -.125)
--Conflict with/among dissertation supervisor and committee [an index of the greater of 3 items] (β = .073, b = 1.967, F = 3.40, r = .021)
Of these, estimated N and conflict, especially, do not show a clear pattern in within-field regressions.

[b]This index is taken as the absolute value of the difference in National Research Council codes for the respective self-identifications of professional specialty - it is only suggestive.

traits is attributed to the institutions that train and employ them.

Clearly, the career patterns literature celebrates the successes of science. And the explanations for success - be they social, psychological, or some unspoken hybrid - tend to be Social Darwinist. The "fittest survive" because they are allegedly trained at the best institutions, which are staffed by the most able scientists, who receive the lion's share of research funds, etc. Such explanations - advanced vigorously by social scientists - have been recapitulated so often that we regard excellence, and its reproduction, as the exclusive property of the "academic metropolis".[62] The undeniable existence of an elite has become confused with an elitism which, in the absence of precise measurement, supports the Social Darwinist tract. Yet the "lesser bred" and "unfit" in the PhD population do indeed survive - in the provinces as well as the metropolises of science.

Contrary to the conventional view, there are many inconsistencies in our own and our forerunners' data. We ask, for instance, how the "indelible mark" of graduate school[63] squares with later recognition of scientists' performance? How much of one's career achievements were ascribed by one's origins?[64] What proportion of institutional or program excellence as rated by the American Council on Education[65] is an outmoded perception of reputation? To what extent is the placement of new PhDs the result of networking and politicking among influential professors from reputable institutions?[66]

It is questions such as these that our 1969-70 PhD cohort data permit us to address. In doing so, we not only reject the conventional view as a self-fulfilling prophecy, but also seek to discern career patterns in their least aggregated forms. That is, we explicitly consider various contingencies and dimensions of careers: discipline of training, sector of employment, primary work activity, the gap between expectation and experience. Although our considerations focus on the first decade, or early careers, of PhDs in six fields, our measures of performance and stature are sufficiently diverse to separate individual from social influences on types of performance. Indeed, we aim to construct several career profiles which link pre- and post-PhD characteristics to the contexts - organizational, intellectual, and reputational - in which careers evolve. For it is the interdependencies of events which distinguish certain careers from others. Why one excels in research may be due as much to "indelible marks" - the enduring effects of ascription-particularism[67] - as to innate ability, creativity, cognitive style, luck, or perseverance.[68]

The difficulty in gauging ascriptive-particularistic influences on career achievements is the very interdependency of events. Science is anything but a random walk! Yet the demographic patterns observed - in scientists' jobs, activities, and migrations - are neither the inevitable product of social forces nor the collective behavior of individual wills.[69] The social determinism of much career patterns analysis is as unpalatable an interpretation as is Social Darwinism. Nonetheless, indelible marks are a social fact that constrain the career paths of many. Surrounding the constraint, it appears to us, is a mythology of people and institutions interlocked inter-generationally to reproduce cadres of accomplished, eminent scientists. While sponsorship is undeniable[70], this is too facile a model. New PhDs are not merely "assigned" to their first position; they must compete. Even if the opportunity structure favors certain competitors, there is a process of screening and evaluating candidates' current competence and professional (not only scholarly) promise that is likely to be specific to field and work-setting.

In an effort to reconstruct the evaluation process, and its suspected variants, we posit an alternative to the myth-shrouded "facile" model. Multiple measures of each of the variables featured in this model are contained in our cohort files. First, we will describe the model, then will proceed to test (and modify) it in terms of the contingencies and dimensions we, and other analysts, have suggested.

The model assumes that, although the PhD is a research degree, a significant proportion of our cohort does little or no research; as noted previously, one-half never publish anything from their dissertation. To these PhDs, their careers feature professional goals and roles that depart from the "academic researcher" stereotype. While some (e.g., Zuckerman and Merton[71]) subordinate non-research roles and suggest they are embraced only when rewards for performing the research role diminish, our model, to the contrary, recognizes that many PhDs <u>never</u> harbor expectations of a productive research career. Indeed, we hypothesize that they are socialized to other roles, such as administration, which are performed and rewarded especially in non-academic contexts, in forms such as high salaries.[72]

After noting entry level or first job placement, one can observe within the time frame of this study, how and to what extent scientists and engineers change roles and employers. A decade, in other words, is sufficient for "early career patterns" to emerge. With, or in spite of, these patterns, we have developed measures of the permanence or change in expectations experienced by our cohort. By combining these data in our analysis, we can examine some of the mythology that sustains the scientific career patterns stereotype, and specify versions of the aforementioned contingent model.

Predicting Career Stature: Measures, Hypotheses, and Equations

We begin our analysis with an overview of correlations between various individual and social predictors of career status and three measures of stature - 1975-78 publications (articles, books, chapters and proceedings), 1976-78 citations (SCI/SSCI-based, including self-citations and citations to multiauthored publications, in which the cohort member was not first author), and calendar year 1979 salary (self-reported in $4000 increments and adjusted upwards for academic year contracts). These correlations are presented in Table 15. While these variables are derived both from archival and survey sources, they are for the most part conventional. This is especially the case for the stature measures, two of which are research-based. One aspect of our analysis and subsequent model-building will be to define additional measures of career performance.

For now, we explore in a series of multiple regression analyses the predictions by various linear combinations of variables of career stature. Four principal hypotheses, derived from the (research role-centered) career patterns literature, are embedded in these regressions:

1) Reputation of PhD institution, department, or program - as measured by Roose-Andersen rating - foretells career success (the "indelible mark" or ascription factor).
2) Eminence of the new PhD's supervisor or sponsor - independent of, or in interaction with institutional reputation - assures success (the particularistic "mentor effect").
3) The taking of a postdoctoral appointment reinforces or replaces both the ascription of the indelible mark and the particularism of the mentor effect in predicting

Table 15. Predicting Career Stature: Zero-Order Correlations Between Various Predictors and Three Measures of Stature, Six Fields Combined

Predictors		Stature Measures		
		Pub	Cite	Sal
Predoc	Chron Age at PhD	-.159	-.171	.021
	BS-PhD Time Lapse	-.196	-.182	.073
	Predoc Pub	.261	.090	.023
Individual				
Postdoc	Postdoc Pos Taken	.286	.314	-.175
	Early Pub	.470	.330	-.036
Mentor/ Committee	Predoc Pub w/Mentor	.193	.184	-.008
	Mentor Aid in 1st Job	.128	.179	-.130
	Mentor Visib/Eminence	-.059	-.023	.040
	Inspiration	.082	.067	-.051
Social				
Dept/Prog/ University	Rating/Rep. of Doc. Dept.	.186	.131	.058

career success (the "postdoc advantage" factor).

4) Early research performance - pre- and post-PhD - is the single best predictor of later productivity and career success (the "research precocity" factor).

Our first set of regressions will incorporate measures of each of the four hypothesized effects or factors (see Table 15). Measures of the three career stature variables will be regressed separately by field on the four (and other) predictors to assess their absolute and relative influence. A similar set of regressions will then be performed for all academically-employed, regardless of field of training, versus non-academics. A third set will focus on non-researchers, by orientation and performance, and a final set will focus on those cohort members indicating a conflict between career expectations and experiences. After reviewing the findings from these four sets of regressions, we will reassess the four hypothesized effects and proceed to additional analyses.

The basic equation used to predict career stature is

(1) Stature = a + b (Early Pubs) + b (Postdoc) + b (Prestige PhD) + b (Mentor Prominence) + b (Mentor Aid) + b (Mentor Inspiration) + b (Mentor Coauthor)

where

Stature = 1975-78 publications (Later Pubs)

or

1976-78 citations (Later Cites)

or

1979 salary (Salary),

as defined in detail above, and

Early Pubs = 1969-72 publications

Postdoc = Whether or not a postdoctoral position was taken (dummy variable)

Prestige PhD = Roose-Andersen rating (0-5 scale, to two decimal places) of quality of department graduate faculty

Mentor Prominence = Questionnaire respondent's perception (1-4 scale) of supervisor's eminence

Mentor Aid = Respondent's rating (1-5) of supervisor's importance in securing of new PhD's first job

Mentor Inspiration = Respondent's rating (1-5) of supervisor's inspiration or stimulation

Mentor Coauthor = Respondent's report of whether or not he/she coauthored any published paper with supervisor (dummy variable).

Due to the competing nature of the hypotheses, the predictors were entered stepwise into the equation, i.e., the independent variable most highly correlated with the dependent enters first, the next most predictive variable, given the relation between the dependent and the first predictor selected, enters second, etc. True, the program determines, on statistical criteria, the order in which predictors enter the equation; thus, stepwise regression has been called atheoretical. In the present context, however, the set of predictors has been selected, on theoretical as well as empirical grounds, from a larger set. Nevertheless, evidence as to the causal priority of the predictors is inconsistent, so by "letting the program choose," we refrain from imposing a causal order on the analysis.

Regressions on Subsets of the Six Fields Combined

The basic equation (1) was run for six different subsets of the 1969-70 cohort predicting each of the three aforementioned stature variables. Table 16 summarizes the results of these 18 equations, showing the stature measure, its chief predictors for that subset (with standardized regression coefficient B and zero-order correlation r in parentheses), and the total variance R^2 explained when all predictors are entered into the equation.[73] The six subsets are respondents in all fields combined, publishers (those with three or more publications since PhD receipt), researchers (those claiming more than one-third time spent on research work), those experiencing a conflict in career expectations (defined as a claimed high research aim in seeking the PhD but fewer than three career publications), those who have spent 90 percent FTE or more in an academic setting during the first decade of their career, and those with a prestigious PhD (defined as an ACE rating of their graduate program faculty of at least 3.0).

Taking the equations in the order of the predicted stature variables, we observe (Table 16-A) that early post-PhD publications is the chief predictor of later publications. Having taken a postdoctoral appointment is the next most frequently significant predictor, (Eqs. 1, 3, 5), while earning the PhD at a highly-rated department is especially significant among the publisher subset (Eq. 2) and those whose early careers have been pursued in academic settings (Eq. 5). Yet none of the R^2 values is particularly impressive, ranging from 4 to 33 percent of the variance explained.

Part B of Table 16 presents the predictors of later citations. Here the R^2 values are again of modest magnitudes and vary from 11.5 to 23 percent. The dominant predictor is the experience of a postdoc with early

Table 16. Equations Predicting Career Stature for Various Subsets of 1969-70 Cohort

Equation Predicting	Chief Predictors (β/r)	Total R^2
A. Later Publications for:		
1. All Fields (N = 538)	Early Pubs (.406/.470) Postdoc (.157/.286) Prestige PhD (.140/.186)	.265
2. Publishers (N = 273)	Early Pubs (.237/.245) Prestige PhD (.150*/.130)	.089
3. Researchers (N = 222)	Early Pubs (.375/.406) Postdoc (.155*/.196)	.206
4. Expectation Conflict (Hi Res Aim, Lo Produce) (N = 117)	no sig preds	.041
5. Those in Academic Setting (N = 276)	Early Pubs (.438/.528) Postdoc (.169/.306) Prestige PhD (.150/.226)	.334
6. Prestigious (N = 267) PhDs	Early Pubs (.402/.442)	.217
B. Later Citations for:		
7. All Fields	Early Pubs (.238/.330) Postdoc (.216/.053)	.180
8. Publishers	Postdoc (.201/.243) Early Pubs (.154/.197)	.115
9. Researchers	Postdoc (.200/.242) Early Pubs (.181/.224)	.132
10. Expectation Conflicts	Postdoc (.367/.393) Early Pubs (.264/.303)	.234
11. Academics	Postdoc (.230/.310) Early Pubs (.149*/.270) Prestige PhD (.132*/.167)	.172
12. Prestigious PhDs	Postdoc (.183/.289) Early Pubs (.172/.259) Mentor Aid (.131*/.222) Prestige PhD (.122/.148)	.158
C. Salary for:		
13. All Fields	Postdoc (-.162/-.175)	.048
14. Publishers	Postdoc (-.175/-.172)	.050
15. Researchers	Postdoc (-.234/-.234)	.074
16. Expectation Conflicts	Early Pubs (-.235*/-.243)	.115
17. Academics	no sig preds	.023
18. Prestigious PhDs	Postdoc (-.242/-.236)	.070

$^*p < .05$; all other $p < .01$

Note: Total R^2 is based on all variables in the equation; chief predictors includes only those significant at $p < .05$.

publications as the second most significant. Only for the academic and prestigious PhD subsets (Eqs. 11 and 12) do other variables emerge as significant, but subordinate predictors. This includes the sole mentor measure, supervisor's aid in securing respondent's first job, to appear in any equation thus far.

Finally, the equations predicting adjusted 1979 salary (Table 16-C) do so with consistently little success, though for four of the six subsets the postdoc experience is negatively related to salary attainment. For those suffering a conflict in career expectations (Eq. 16), lack of early publications augurs later salary attainment.[74] None of the conventional predictors, however, seem positively relevant to this measure of career stature.

The preliminary evidence, then, favors the research precocity factor followed by the postdoc advantage and indelible mark factors in explaining career stature for six aggregates of the 1969-70 PhD cohort. For the academically-employed[75] and research-oriented members of the cohort, these factors are salient, but leave much unaccounted for. This conclusion raises two intriguing analytical questions: Are there field-specific profiles which distinctively combine factors to predict career stature? And are there other, less familiar or conventional variables that may predict stature as well as or better than those contained in Eq. (1)? We address these questions in order.

Field-Specific Regressions

In the present analysis, we disaggregate the cohort into its six disciplinary or field components. Before we examine the results of these regressions, we think it informative to compare the mean (and standard deviation) values for two of the stature variables and two of the predictors. Table 17 shows these comparisons plus the Pearson correlations for the two dependent variables and the two publication - early and later - measures.

Some striking variations are apparent. Only column 3, the prestige PhD values (which are restricted by the ACE 0-5 scale), reveals negligible differences, though the mean Sociology rating is the clear laggard (its N is the smallest while its standard deviation is largest). The later publication and citation measures, columns 1 and 2, indicate the research productivity norms that set biochemistry apart from the other five fields, especially electrical engineering which seems veritably indifferent to research citation in the open literature. As the bibliographic analyses included in assessing the "value of the dissertation" revealed, however, publication and citation distribution are highly skewed; a few scientists are prolific publishers, while an even more select set of papers receive extensive citation. Logarithmic transformation of these distributions would reduce the potential effect of these respective producers and highly-cited scientists in multiple regression analyses. In the forthcoming analyses, log values of these variables were substituted for the raw data. However, the zero-order correlations between, e.g., later publications and logged later publications, exceeded .9. Furthermore, the b coefficients were altered only slightly (to the hundredths place), so that all equations featuring logged variables were virtually identical (in b and R^2 values) to those featuring the variables' unlogged counterparts. Below, therefore, we report only the "raw data" equations.

Again, basic equation (1) was run by field to predict separately the three career stature variables. As columns 5 and 6 of Table 17 showed, early and later publications and later publications and citations are

Table 17. Means and Correlations of Selected Career Variables, By Field

Field	(N)	(1) Later Pubs Mean (S.D.)	(2) Later Cites	(3) Prestige PhD	(4) Early Pubs	(5) $r_{1.2}$	(6) $r_{1.4}$
Physics	(87)	3.01 (4.25)	11.58 (31.69)	2.98 (.92)	2.34 (2.41)	.443	.529
Sociology	(78)	3.31 (4.44)	5.64 (7.77)	2.68 (.99)	2.19 (3.42)	.672	.673
Zoology	(102)	4.29 (5.51)	7.86 (13.59)	3.00 (.80)	2.76 (2.95)	.364	.623
Electrical Engineering	(87)	2.20 (5.67)	1.67 (4.35)	3.15 (.77)	1.60 (1.97)	.752	.190
Biochemistry	(96)	5.57 (5.10)	28.48 (45.68)	2.99 (.91)	3.72 (2.83)	.405	.320
Psychology	(88)	2.41 (4.16)	8.89 (17.00)	2.83 (.80)	2.14 (3.40)	.518	.344

Note: Pubs includes only journal articles, books, chapters, and proceedings.

substantially, but not perfectly, correlated.[76]

Table 18 summarizes, by field, the equations predicting career stature. In Part A, we examine the suspected field disparities. The common thread is early publications as the chief or sole predictor in five fields. Having taken a postdoc is significant only in sociology, but two mentor measures - eminence in sociology, inspiration in biochemistry - are predictive of later publications. The conventional set of predictors is most explanatory in the heavily academic fields, sociology (R^2 = .504) and zoology (.428). "Success" in electrical engineering seems governed, as hinted at earlier, by a different dynamic altogether.

In Part B, early publications retains its predictive power quite broadly, though a prestigious PhD surfaces in physics, zoology, and psychology. One-half the variance in sociologists' later citations (Eq. 8) is explained by the basic equation, while psychologists' stature as measured by citations (Eq. 12) nearly doubles the variance in the publication equation (Eq. 6). Coauthoring with one's mentor appears for the first time in any equation (zoology, Eq. 9). For three fields, however, there is a decrease in R^2 from A to B; in two of these fields, the decrease is substantial (see Eqs. 7 and 9).

Part C of Table 18 is predictably disappointing in its illumination of factors that contribute to salary attainment. No more than 13.5% of the variance is explained (psychology, Eq. 18). In all, five different variables are significantly related to salary, a different one in each of five fields (nothing is predictive in electrical engineering). These findings include a contradiction as well: mentor's inspiration is a negative predictor of 1979 salary in physics, whereas coauthoring with one's mentor is a positive influence in zoology. The mentor issue, it seems, is

Table 18. Equations Predicting Career Stature for Individual Fields of 1969-70 Cohort

Equation Predicting	Chief Predictors (ß/r)	Total R^2
A. Later Pubs		
1. Physics	Early Pubs (.489/.529)	.381
2. Sociology	Early Pubs (.638/.673) Mentor Eminence (.188*/.133) Postdoc (.154**/.157)	.504
3. Zoology	Early Pubs (.531/.623)	.428
4. Electrical Engineering	no sig. predictors	.084
5. Biochemistry	Early Pubs (.288/.320) Mentor Inspiration (.183**/.166)	.159
6. Psychology	Early Pubs (.260*/.344)	.219
B. Later Cites		
7. Physics	Prestige PhD (.252*/.336)	.202
8. Sociology	Early Pubs (.652/.688)	.493
9. Zoology	Early Pubs (.185**/.346) Prestige PhD (.233*/.332) Mentor Coauth (.177**/.262)	.228
10. Electrical Engineering	Early Pubs (.291*/.280)	.117
11. Biochemistry	Early Pubs (.223*/.273) Postdoc (.182**/.242)	.117
12. Psychology	Early Pubs (.560/.558) Postdoc (.244/.347) Prestige PhD (.225*/.081) Mentor Eminence (.208**/-.040)	.419
C. Salary		
13. Physics	Mentor Inspiration (-.209**/-.211)	.132
14. Sociology	Early Pubs (.251*/.186)	.092
15. Zoology	Mentor Coauth (.214*/.242)	.094
16. Electrical Engineering	no sig preds	.018
17. Biochemistry	Postdoc (-.179**/-.144)	.054
18. Psychology	Prestige PhD (.200**/.168)	.135

*$p < .05$; **$p < .10$; all other $p < .01$

Note: Total R^2 is based on all variables in the equation; chief predictors includes only those significant at $p < .10$.

anything but resolved.

What, then, can we infer from these field-specific equations? Perhaps the principal inference is that some factors are general; some, field-specific. Thus, aggregating across fields will obscure certain effects. This is particularly clear in the case of electrical engineering. Publication in this field is not as highly rewarded and citation rates are low (SCI counts); hence, the modest R^2 values in Parts A and B of Table 18. Yet, extracting for analysis the 52 electrical engineers (49 percent of this field's sample) who spent at least 90 percent of their post-PhD decade in non-academic settings yields the following: early publications significantly predict both later publication and citation (R^2 = .205 and .238, respectively). These values more than double the R^2's for the field sample as a whole. What this suggests is that some industrial employers do reward publication activity. (Predicting salary for the subset of 52, however, was as much a washout as the equations reported earlier.)

Second, this overall assessment of the four hypothesized factors in, or effects on, measures of career stature bears mixed evidence. Early publication is indeed the best harbinger of later research activity, yet it is responsible - regardless of the subset, aggregate, or discipline in question - for less than half of the variation in career stature. Post-doctoral experience and prestige of PhD are notable but less consistent in predicting later career success (where "later" is only a decade after receipt of the PhD). The mentor measures show only occasionally.

Third, therefore, is a recommendation to reconsider the conventional set of career stature predictors, as well as our measures of stature themselves. Probing our questionnaire data, we have defined alternative sets and manipulated them as above. In the following section, we review these findings and discuss both their theoretical and empirical implications.

Regressions with Alternative Predictors and Stature Indicators

The burden of this section is to find and test a set of variables that differ from those prevalent in the career patterns literature. Based on our findings heretofore, we face two challenges: (i) to justify our measures of career stature or augment them with another, less research-oriented measure, and (ii) to substitute variables excluded from conventional analyses and untried above for those hypothesized as pivotal in predicting early career success.

For the first challenge, we turn to our questionnaire. One item centers on "supervisory responsibility" in the current job, measured on a six-point ordinal scale:

1) supervise no personnel
2) responsible for indirect or staff supervision (no line authority)
3) supervise students (e.g., graduate assistants)
4) supervise team, unit, project, or section
5) manage major department or division
6) general management of organization.

To adopt this item as a surrogate of career stature recognizes the "administrative-managerial" dimension which has become central in scientific work, yet is a role distinct from research. Indeed, in non-academic settings and in exclusively research-oriented organizations appended to universities, the supervisor/administrator is handsomely rewarded for wielding the entrepreneurial and interpersonal skills demanded by Big Science.[77] Thus, this "supervisory responsibility" measure joins our other dependent variables as a candidate for explanation.

In response to the second challenge to find innovative alternatives to the predictor variables already tested, we nominate the following derived from our questionnaire:

Supervisory Work (1st Job) = the counterpart 6-point scale to the "supervisory responsibility" measure of career stature defined above.

Time Lapse = elapsed years between receipt of the baccalaureate degree ("B.S.") and the doctorate ("PhD").

Field Shift = change in specialty from area of dissertation to current professional identification (using NRC codes).

Predoctoral Publications - number of papers published in or prior to 1970.

Research Time (1st Job) = percent of time devoted to research in first job.

The alternative equation we seek to test, therefore, is

(2) Stature = a + b [Super. Work (1st)] + b [Time] + b [Shift] + b [Predoc Pubs] + b [Research Time (1st)].

Before we report the results of these regressions, however, some comparison of the data in raw form would be informative. These data are presented in Table 19.

In addition to the five alternative predictors defined, two others are highlighted in Table 19 (columns 4 and 5). Mean age at PhD shows a tendency in the physical sciences to obtain the degree by one's late 20's; the opposite tendency holds for social sciences, as exemplified here by sociology. The high correlation repeatedly observed between age and elapsed time[78] is evident here, too, so much so that only the latter will be entered into the equations that follow. The other variable not utilized

Table 19. Mean Values of Alternative Predictors and One Measure of Career Stature, by Field

Field	(1) Predoc Pubs	(2) Field Shift[a]	(3) Time BS-PhD Lapse (Years)	(4) Age at PhD (Years)	(5) N Dissertations Directed by Supervisor	(6) Research Time on 1st Job (%)	(7) Supervision Level on 1st Job[b]	(8) Supervision Level on 1979[b] Job
Physics	.93	85.54	7.45	29.44	9.68	58.11	1.89	3.29
Sociology	.43	11.24	10.31	34.44	16.54	25.46	2.26	3.76
Zoology	1.32	6.28	7.90	30.32	12.97	43.81	2.13	3.39
Electrical Engineering	.32	11.77	8.10	30.26	11.73	43.06	1.85	3.42
Biochemistry	.52	10.51	6.41	28.81	8.97	85.00	1.92	3.68
Psychology	1.00	16.32	6.82	30.38	16.99	26.29	2.36	3.41

[a] A crude index based on NRC specialty code differences.

[b] Scale values: 1 = no personnel, 2 = indirect or staff supervisor, 3 = students, 4 = team, unit, project, or section, 5 = major department or division, 6 = general management.

below was intended to capture the experience of our respondents' supervisors in directing dissertations. The high means in psychology and sociology may be indicative of the tendency to concentrate dissertation direction among a few senior faculty. The team approach to research in biochemistry and physics may likewise distribute this labor over a larger pool of faculty. With no theoretical rationale for linking this variable to the respondent's supervisory responsibility in 1979, however, we omitted this mentor measure from the regressions described by alternative equation (2).

Table 20 summarizes by field the alternative predictions of career stature. Note that the reporting format has changed with stature measures listed at the left and the statistically significant predictors for each noted by lower case letters next to the variance explained in each of the 24 equations (4 x 6 fields).

Comparing across fields for each stature measure, we see that predoctoral publications and field shift are predictive of later supervisory responsibility in three fields. While small in magnitude, the R^2 values exceed those in all fields except psychology derived from the salary predictions discussed earlier (Table 18, Eqs. 13-18). The second row of Table 20 predicting later publications indicates that the alternative set of variables do not fare as well as the conventional set. Two exceptions nevertheless warrant attention. One is the relative success of the alternative set in predicting later publication in electrical engineering (R^2 = .356 vs. .084 in Table 18-A, Eq. 4); the other is the research time variable (1st job) that is the sole predictor in the two physical science fields and a primary and tertiary predictor, respectively, in sociology and electrical engineering. It seems to relegate predoctoral publications, a close surrogate of "early publications," to a background position, except

Table 20. Alternative Predictors of Career Stature

Stature Measures	R^2 and Significant Predictors* in Field					
	Physics	Sociology	Zoology	Electrical Engineering	Biochemistry	Psychology
Supervisory Work (current)	.246 abc	.110 be	.195 cde	.120 c	.122 e	.121
Later Pubs	.249 a	.252 ab	.282 c	.356 cbad	.077 a	.246 d
Later Cites	.328 cd	.246 a	.098 a	.272 adb	.097 b	.220 ae
Salary (current)	.187 a	.053	.160 e	.105	.153 a	.209 bec

*Predictor Codes:

a = research time (1st job)
b = BS-PhD time lapse (shorter)
c = predoctoral publications
d = supervisory work (1st job)
e = field shift (from dissertation area to current professional identification)
blank = no significant predictors

The sign of all coefficients is positive - but note that "b" reflects shorter times - except for: a - biochemistry salary; b - psychology salary; c - electrical engineering supervisory work and psychology salary; e - sociology supervisory work, biochemistry supervisory work, and psychology citations.

Significance of β of predictor in Eq. (22) = $\underline{p} < .10$.

R^2 based on all five independent variables included in the estimation.

in zoology and electrical engineering. Could this suggest that a simple query as to research orientation addressed to a new PhD would be a better predictor of later research productivity than counting early publications? Inclusion of such an item in the NRC doctorate records questionnaire provides an interesting source of data.

The predictions of later citations are more erratic in Table 20. For physics the alternative set, in terms of R^2, excels the conventional set (.328 vs. 202 in Table 18, Eq. 7). A similar finding emerges for electrical engineering as well. In both of these fields, supervisory work (1st job) is a secondary predictor. Note that research time on the first job is again the most general predictor, dominating predoctoral publications in most fields. For the remaining fields, the alternative predictors yield inferior explanations. This pattern is reversed for the row of salary predictions, however, insofar as the alternative set explains much more variance in five of the six fields. Percentage of time spent in research during the first job leads the explanation in the physical science fields once more. It is this variable that is significant in eleven of the 24 equations of Table 20. The remaining four variables in Eq. (2) are significant a total of 25 times.

The upshot of these regressions underscores our earlier findings. The field - its research leaders, professional societies, funders - in which one carves a career defines its parameters of success. In seeking common parameters, we have no doubt missed capturing activities and rewards that are unique to fields. The starkest evidence that a significant portion of stature is field-specific are R^2 values that rarely exceed .5. Those portions of success synonymous with research accomplishments, remuneration, and administrative responsibility have been reflected in various equations.

Yet irrespective of a field or categorical profile, much remains to be explained.

Conclusions and Prospects for Predicting Career Stature

Our findings compel us to reconsider the four hypothesized effects which framed the analyses of this section. One general observation is that the four effects - ascription (by degree), mentor, postdoc, and early research - are anchored in an "academic" career profile. For those whose jobs, motivations, and performance unfold in non-academic contexts, these effects appear to be weak or irrelevant. Even the superior skills assumed to be acquired from a prestigious doctoral program have most predictive power for academics (Table 16), and generally rather little independent predictive impact on career stature as we have defined it.

Stature, of course, is an achieved status which combines quantifiable outcomes of performance with a gloss of perception that indeed the "performer" is <u>more</u> than competent, but excellent in the execution of professional roles. The four proxies employed here appear lacking as precise indicators of this. Thus, like others who have recently undertaken disaggregated analyses of scientific careers (e.g., Reskin[79]), we recommend that new proxies for career stature - performance, achievement, etc. - be developed. That these proxies will be context-specific and sensitive to variations in role-definitions is essential. That is, research in an industrial lab may not remotely resemble research conducted in an academic lab. Likewise, managing those respective labs may require disparate skills and responsibilities. And underlying all of these differences in job desiderata are the intellectual problems of materials, apparatus, and experimentation which give a science its peculiar designations, esoteric specialization, and eminently local character.[80] To discern patterns that do not encompass these differences as well as the demographic similarities in which career analyses often originate, e.g., the 1969-70 PhD cohort, is to overlook a substantial part of the phenomenon.

What our empirical conclusions demand is both a more comprehensive and sophisticated theoretical framework for prospective career patterns analysis. We must augment the individual, and especially the social, variables listed in Table 15 with predictors of stature that bear upon early scientific performance. For example, though mentors can be pivotal in securing jobs and, in turn, opportunities for accumulating competitive advantages in research,[81] their most influential aid may come in the form of informally bridging the neophyte and extra-local contacts, e.g., editors and funding agents. Such introductions to gatekeepers can pay rich dividends down the road long after "early promise" has been replaced by a solid "track record" and senior status is assured. Perhaps analysis over the full 30-40 year duration of a career would disclose the workings of such informal ties and long-deferred successes. Of course, it is dubious to expect that measures can capture any overwhelming portion of the variance in tracking future scientific careers.

In sum, what has been demonstrated in this section is theoretical plenty amidst well-circumscribed evidence; nevertheless, the evidence has eluded the bounty of our predictions. What has been good for explaining careers that approximate the academic physical science stereotype is not as good when the science, its context, and its definition of career success diversify. As analysts, we face a more complex, multiple reality. To understand it, we cannot rely on our old tools and time frames. Career patterns analysis requires more.

OBSERVATIONS AND RECOMMENDATIONS

Observations

As stated in the Introduction, this project was intended to analyze "assumed relationships" concerning elements of the doctoral training process and scientific careers. Specific hypotheses based on the earlier study by Porter and Wolfle[82] were examined.

How does the dissertation fare in the eyes of PhDs in terms of its training value? Very well. On a variety of questionnaire items and combined indices, respondents are extremely favorably disposed to their dissertations. They reiterate this support in terms of not favoring a variety of possible changes in the format.

How does the dissertation fare in terms of research value? Quite well. In terms of subjective judgments by these PhDs, research value of the dissertation is pretty good, though not exceptional. In terms of our objective indicators, the dissertation is certainly reputable. On average, one finds almost one open literature publication per dissertation, although only 50% of these PhDs published anything from their dissertations (i.e., the other 50% publishing averaged about two publications per dissertation). In addition, on average another 0.8 publications result from continuation of the dissertation research post-PhD. Citation rates to these publications are slightly greater than to other publications by these same scientists over the course of the first decade of their professional careers. In sum, dissertations are a fount of good science.

One of our "pet" hypotheses was that those PhDs who do not go on to pursue academic or research-oriented careers would have severe misgivings about the dissertation. Results showed only a single statistically significant distinction, on practicum/internship in lieu of the dissertation, with persons who provide professional services relatively more supportive (though still quite negative). What is striking is that no positive support, on average, emerged for any of the alternatives presented, nor did strong dissatisfaction with current practices. Looking back after a decade, even those PhDs who have not pursued research actively reflect with favor upon the dissertation. Even the ABDs queried, who lack only completion of the dissertation to attain the doctorate, do not express general dissatisfaction with that requirement. Rather than calling for change, therefore, we have come upon a strong endorsement of current practice in general.

We have gathered a fair bit of process information as to the nature of the activities involved in selecting, guiding, and producing dissertations and with respect to other aspects of graduate training. Selection of graduate programs appears to involve a complex balancing of multiple factors, with some field differences. Notable field differences emerged in terms of selection of a dissertation topic, with some leaning heavily upon faculty advisors and others predominantly residing in the individual's preferences. Median time to complete a dissertation ranges from about one year in the social sciences and engineering to almost two years in the physical sciences surveyed. The role of the faculty supervisor in this process appears quite important, with repercussions spreading beyond the doctorate on early career directions and dedication to research. There is a strong status differential in the relationship between students and supervisors that, fortunately, appears rarely to lead to problems. Conversely, the role of the dissertation committee appears almost negligible. Supervisors tend toward prominence with relatively few supervising relatively many dissertations; it would seem desirable for students to make sure that the supervisor selected can provide ample advice and assistance.

Returning to the rationale for deciding to seek a PhD, research as a career aim nudges out teaching. However, for a substantial number of people, research is dominated by some other aim, e.g., teaching or professional service. Teaching dominates research in sociology and zoology; professional practice and teaching together dominate research in psychology and electrical engineering. Graduate training policies clearly ought to go beyond treatment of the PhD simply as a research degree.

Federal research grants and fellowships were instrumental to completion of their doctoral training, each for a majority of our scientists. The range across fields is extreme, with sociology at the bottom. Not surprisingly, full-time work is a correlate of completion of the dissertation for a sizeable percentage of sociologists - more than any other field. Curtailment of federal aid would appear to have significant implications for graduate study. It is also likely that redirection of federal aid largely to research grant support could also tend to stress the dissertation, e.g., where "big science" experiments of long term and large team character may provide a difficult context for dissertation research.

Facilities for the conduct of research are rated quite good for the dissertation period by this 1969-70 cohort, considerably better than their present facilities. Current facilities are rated significantly poorer for academics than for others. Coming from a comparative base, the 1969-70 psychologists appear to conduct significantly less research than their 1963-64 counterparts, measured either in terms of publications throughout the first post-PhD decade or in terms of percent time devoted to research.

These signals taken together suggest concern for the state of scientific research. Pending federal policy changes could exacerbate the situation for some fields, in particular, the social sciences.

The dissertation is clearly not of equal value for all. Theoretical, as compared to empirical/experimental, dissertations tend to be less fulfilling. Overall, zoologists find the dissertation more satisfying than any other field on a number of grounds - general satisfaction, total related publications, personal interest in choice of topic, emphasis on originality and significance in evaluating their dissertations, personal assessment of how valuable the research findings were, training value, inclination to continue the research beyond the dissertation, and relevance to the job one year, and about one decade, post-PhD. Again, we must put this in perspective in that all fields are positive on the dissertation on all counts; the zoologists are just most positive.

An interesting finding is that dissertation-derived publications are significantly more apt to be single-authored than other publications by the same scientist. This raises potential questions as to whether the individual orientation of the dissertation research is the ideal training for what appears to be more team-oriented research taking place after the doctorate.

Another interest in this study was to examine the relationship between graduate training practices and later careers. First of all, we should note that a substantial fraction (36%) of our respondents have spent less than half of their careers in academia. Overall, our sample spends only one-third of their time a decade post-PhD on research. Taken together, this suggests that we must broaden our criteria in considering these scientists; the stereotypical research-dedicated academic is not the only viable career model. Thus, we examined two additional career development measures - salary and supervisory responsibility - in addition to publications and citations. Unfortunately, our attempt to predict levels of development on these additional indicators was not highly successful. As part of our proverbial call for further research, it appears to us that sociologists of science would do well to examine such alternative career productivity measures.

Our first modeling efforts were devoted to trying to predict dissertation value. The profile that emerges suggests that one's perception of dissertation research value generally tracks one's perception of the amount learned and the general value of the experience more than it tracks publication and citation rates for dissertation research. Perceived research value seems more strongly linked to supervisor stimulation than to other dissertation valuations. We considered a number of potential predictors of these various dissertation valuations, including what seemed to be individual choice factors and those more likely to be sensitive to graduate training and federal aid policies. Only modest amounts of the variance in the dependent measures are accounted for, with within-field regressions more effective than those across fields, and the perceptual measures easier to predict than the publication and citation output measures. The dominant influence seems to be the perceived criteria for evaluation of one's dissertation. Pressure toward scientific significance, originality, and, to a lesser degree, positive findings is associated with enhanced output; pressure toward relevance runs counter to publications and citations. Beginning the dissertation research early and receiving financial support in conjunction with that research also associate with increased productivity.

With respect to training value and general valuation of the dissertation, relevance as an evaluation criterion is a positive predicter, a reversal of its influence on research output. Scientific significance is the most consistent positive predictor, and demonstration of competence enters as a positive correlate of training and general value also. Beginning the dissertation early again relates to favorable evaluations. Satisfaction with training and the dissertation overall also associate with finding technicians and seminars helpful, good research facilities, and shorter elapsed time between the bachelors and doctorate. An interesting twist appears with quality ratings in that more prestigious departments associate with more dissertation publications and citations, but also with less satisfaction with dissertation training value and general worth. Selection of dissertation topic based on scientific importance is a favorable predictor for both sorts of measures; selection based on personal interest relates positively to training/general affect, but negatively to output (publications and citations). Supervisor prominence helps on all counts, but one seems to do better choosing a supervisor who, all else equal, has guided fewer dissertations to completion. Comparisons across the regressions by field shows an interesting result when a tally is made of the number of times that a field broke with the general pattern for the various independent variables examined. The field deviating most from the remainder of our six was physics; those deviating least were the social sciences.

We next tried to model factors carrying influence beyond the doctorate. Scanning a set of regressions suggested a loose general model as follows:

- Initial inclination toward research and academic career predicts satisfactory graduate training experiences and research-oriented post-PhD careers

- Close relationship with dissertation supervisor seems to contribute to supervisor assistance in attaining the first job, continuation of the dissertation research, and taking a postdoc. It also relates to a good dissertation experience.
- All of these factors, in turn, except for continuation of the dissertation research per se and including initial orientation to research and to academic careers, associate with increased time devoted to research a decade post-PhD.

Our final set of models concerns career productivity measures. These include publications, citations, and, as previously noted, salary and supervisory responsibility. Our best predictors of publication and citation activity are:

- early career publication, a predictor that appears very generally across field and across various other subsets of our respondent set (e.g., researchers);
- taking a postdoc, the next most general and strongest predictor (and a negative predictor of salary, possibly reflecting the fact that academics tend to be high publishers and low paid); and
- prestige of the PhD-granting department, the other noteworthy predictor of career scientific outputs.

In addition to the traditional and non-traditional dependent measures examined, we also explored a set of non-traditional predictors. The most interesting finding here was that percent time spent on research on the first post-PhD job was a more effective predictor of later career publications and citations than a measure of early publication activity. One might surmise that such simple indicators as expressed career preferences or type of first job (as obtained in the annual NRC Survey of Earned Doctorates) might tap individual intentions to predict career directions more effectively than the early output indicators do. This would also be a fruitful area for indicator research and development.

In closing this discussion, it should be noted that most of the modelling efforts generate relatively low percentages of variance accounted for. This suggests a number of possible interpretations. For one, none of the simple, graduate period measures would seem to fix the direction of individual careers substantially. For another, the issue of whether field differences make the generation of a general science model inappropriate are not resolved by these data. In some respects, models seem to hold quite well across disciplines; in others, within-field differences seem to be substantial. Given this sort of uncertainty, it would behoove researchers to circumscribe their studies carefully and beware of facile generalizations (e.g., of studies on biochemists to all scientists)[83].

Ideas

While our respondents, even notable subsets of our sample, failed to endorse any of the proposed changes in dissertation practices, they did offer a number of creative suggestions. Here is a condensed list of ideas that merit consideration for certain programs.

- (physicist) Not enough effort is made to help students see the "big picture" in looking for meaningful research topics. A course in strategic thinking should be included . . . Perhaps this could be given in conjunction with the business school as a joint program. I am certain that such an effort would lead to more meaningful physics but possibly fewer grad student "slaves."

- (zoologist) Prior research experience will greatly improve the quality of the PhD dissertation in most cases - and can furthermore result in some publications that may improve the person's career opportunities. . .

- (biochemist) The "rotation" concept, where each student spent a month in one of the laboratories before deciding about an advisor was tremendously broadening and helpful.

- (electrical engineer) Instead of a language requirement - although many have none - have a choice of several enrichment courses for the purpose of
    1) improving teaching skills
    2) management training
    3) project direction
    4) research game theory - how to get money, etc.

- (physicist) [take full advantage of the dissertation to teach research management] - it forces the candidate to learn how to structure the analysis of the problem; it requires him to find ways to marshall the needed resources. . .

- (sociologist) No one in grad school taught me how to manage research, i.e., to break down the job into discrete sub-tasks, estimate man-days, draw up work schedules, etc. . . . There are opportunities for research-oriented people outside of academia, but they must be trained to work in a real world environment.

- (sociologist) It is important that creative thinking, group work, practicality, and efficiency be promoted.

- (electrical engineer) Many PhDs are not well supervised for real world contributions simply because the staffs do not perceive the problems. A solution would be to require outside connections to the private business sector by both staff and the candidate.

- (physicist) [we might do well to beware of radical shifts in federal doctoral student support such that research project assistantships became the sole significant source of aid] Experiments in physics are generally becoming much bigger with long lead times--up to 7 years. It is difficult for students to be original in an experiment which involves 25 senior physicists and costs many years.

- (psychologist) The stigma against non-academic jobs is a problem. . . . Graduates should be encouraged to create jobs by finding where their skills can help an organization, institution, or corporation.

- (biochemist) I believe the word "philosophy" is appropriate to the Ph.D. degree. It conveys more a way of life than simple job training or acquisition of skills.

- (biochemist) Graduate work today I find far too highly specialized. We are turning out miniature idiot-savants. [re: multiple short research projects] (physicist) I would like to see topics broad based in the field of interest rather than several closely related undertakings. It could result in more "rounded" professionals.

- (biochemist) After six years of graduate study all students know what the big research plums are, but only few have the foggiest notion about what sort of information the world needs. Related disciplines are ludicrously isolated in the university.

- (psychologist) It would be helpful if there could be standard guidelines across institutions so that so much is not left up to individual advisors. There could also be more flexibility in programs to accommodate students with interest in more than one specialty area.

- (physicist) I feel there was no attempt by the advisor to delve into the question of what I wanted to do - teach - and how to accomplish same, i.e., publish. Alternately, I could have oriented my studies to generating a pile of publications.

- (zoologist) Dissertation chapters should be in form of manuscripts whenever possible.

- (physicist) Ph.D. program should be about 4 years from BS-Ph.D., with more emphasis on post-doctoral fellowships of, say, 2 years to refine research skills and subspecialize. This suggestion provides more milestones and more convenient drop-out points for the non-academic people.

- (electrical engineer) I believe that the type of program best suited for non-research oriented post masters engineering education is already provided by the various professional engineering degree programs (E.E., C.E., etc.) . . . unfortunately these have been given a bad name by schools that use them as a consolation prize for failing a PhD program.

- (psychologist) The PhD should be a research degree with other doctorates available for certain areas - e.g., law, optometry, engineering. Some areas are probably not ready for purely applied degrees - e.g., psychology.

Recommendations

Our data convey the notion that scientists are not a homogeneous mass; they differ significantly by field, by work activities, and by commitment to research. Given such heterogeneity, we would have anticipated being able to find diverse perspectives on how to conduct graduate training with specific reference to the dissertation. While we certainly found individual perceptions differing, we found no substantial subset of our 645 respondents willing to lend substantial support to serious criticism of present practices or to explicit alternatives to those. These PhDs, and even a substantial number of the ABDs interviewed, heartily support the PhD training process with its heavy commitment to the doctoral dissertation as is. Were this research study to be gauged on the basis of "positive" findings, we would be in somewhat of a quandary: we anticipated being able to report and advocate some changes in current practice. Instead, our first recommendation would be to proceed cautiously in any remodeling of the PhD process.

Had we found substantial inclination to change, we would have suggested consideration of indicators of scientific morale, tabulation of alternate doctoral degree programs and graduates, and performance measurements on same--but we have little to back such a call. We would urge ongoing monitoring of such factors as the shift away from academic employment for PhDs. We suspect that the perspectives of 1979-80 PhDs might be less positive due to the altered market place.

Again, we confess some surprise to uncovering several indicators of a slumping research enterprise. Where we anticipated tabulating evidence to support the publication explosion, we found that the 1969-70 cohort of psychologists published considerably less over time than their 1963-64 colleagues.[84] They also are devoting proportionally less time to research.

Moreover, several of our cross-field measures for the 1969-70 PhDs queried in 1979 suggest a possible movement away from research - although not conclusively. It would seem particularly important to begin to monitor and analyze various process factors pertinent to scientific research as well as output measures. Such process measures should probably attend to the graduate training process as well as to other aspects of how scientists conduct their studies, the status of their facilities, and the importance of various modes of researcher interaction, such as interdisciplinarity. Process measures, in short, demand finer-grained, observation-based studies than have heretofore been embraced by science indicators researchers. The contingencies of research organization may hold the very keys to explaining career productivity and development that "indicators" have only detected. One specific direction for study is the movement of a substantial number of PhDs toward administration and away from research within a decade of their doctorates. It would be useful to know the extent of this movement, how it changes over time, and what factors affect it (e.g., salaries, research support).

Finally, we suggest investigation of the NRC doctoral records file as a useful source of potential leading indicators of research productivity. Our results suggest two measures tapped by the Survey of Earned Doctorates as promising indicators of individual research effort a decade later--the extent to which research and development are denoted as primary or secondary work activities for the first job and the taking of a postdoctoral fellowship or research associateship. These two measures should be examined for various aggregations of scientists for whom research output measures are available. If they do indeed predict effectively, they should be considered for Science Indicators.

References and Notes

[1]A. L. Porter and D. Wolfle, "Utility of the Doctoral Dissertation," American Psychologist 30, 1975, 1054-1061.

[2]Lindsey R. Harmon, "A Century of Doctorates: Data Analyses of Growth and Change," Washington, D.C.: National Academy of Sciences, 1978.

[3]L. Wilson, The Academic Man: Sociology of a Profession, New York: Oxford University Press, 1942.

[4]M. J. Mulkay, "Methodology in the Sociology of Science: Some Reflections on the Study of Radio Astronomy," Social Science Information 13, 1974, 107-119; S. W. Woolgar, "Writing an Intellectual History of Scientific Development: The Use of Discovery Accounts," Social Studies of Science 6, 1976, 395-422.

[5]K. M. Wilson, "Of Time and the Doctorate," Report of an Inquiry into the Duration of Doctoral Study, Atlanta, GA: Southern Regional Education Board, 1965.

[6]The main categories unrepresented in the sample are Arts and Humanities, professional fields (e.g., business administration, religion), and education. However, neither can it be claimed that a field is representative of a major category (e.g., physics of mathematics, chemistry, and earth sciences, all falling within "physical sciences") nor that any set of fields is truly repesentative of "Science." As a consequence, while we examined weighted sample tabulations, these were not deemed constructive. Results averaged for all our respondents can be complemented by averages of the six individual field tabulations to provide two general indicators (which tend to correspond closely).

[7] We had to go to Dissertation Abstracts in 1971 to attain this initial number in zoology, but were able to return to these criteria upon receiving the results of the unique names search.

[8] A. L. Porter, "Citation Analysis: Queries and Caveats," Social Studies of Science 7, 1977, 257-267; J. Margolis, "Citation Indexing and Evaluation of Scientific Papers," Science 155 (10 March 1967) 1213-1219.

[9] Some mysterious force seems to impel data files slightly away from their nominal totals; we intended 200/field. We ended up with 198 in biochemistry, 199 in sociology, 200 in zoology and physics, and 201 in psychology and electrical engineering.

[10] We excluded foreign addresses as well as those for whom we were unable to obtain an address by this point (there were delayed mailings up to a couple weeks for slow alumni office responses, etc.). Correcting for 9 corrections in field identification, 16 mis-identified individuals (wrong person, field, or year of doctorate), 2 deceased, 3 out of country (not forwarded by alumni offices who would not provide addresses directly to us), 1 incapacitated by a heart attack, and 67 returned as undeliverable, our "corrected" deliverable sample consisted of 151 physicists, 156 biochemists, 155 zoologists, 162 electrical engineers, 156 psychologists, and 142 sociologists.

[11] After the initial mailing in March, 1979, two reminder postcards, a second questionnaire mailing (May), and an attempted phone call reminder were employed. By July 10, 1979, 639 of the eventual 645 usable responses were in hand.

[12] The wording varied according to the number of publications we had retrieved. Those showing 1 or 2 publications were asked to correct/augment, but the cover letter emphasized our interest in non-researchers, different from the cover letter for those with more publications (see Appendix A). Those with 0 identified publications were not asked about publications. This implies a biasing toward under-reporting their publications, traded off for an enhanced response rate since our previous study indicated a tendency to under-sample those less oriented to research - A. L. Porter and D. Wolfle, "Utility of the Doctoral Dissertation," American Psychologist 30, 1975, 1054-1061.

[13] Citations for 1979 were received too late to include in this analysis.

[14] The algorithm searched on 4 characters of the first author's last name, 1 character of the publication name (e.g., journal title), volume, and year. We included our 645 respondents' publications plus those of the 128 psychologists from our earlier study (1963-64 PhDs). The 1970-78 search yielded 14001 citations. There seems, however, to have been a systematic undercounting by the computerized search so citations should be considered on a relative, not absolute, basis here.

[15] This search was restricted to the sociologists and those of the "new" and "old" (those from the previous study[1] of 1963-64 PhDs) psychologists whose publications related to the SSCI. We excluded pieces that appeared likely to be cited in SCI journals. This would tend to underestimate citations for some psychologists. However, the hand search is able to capture slightly imperfect citations that the automated search would miss (e.g., those with a one digit discrepancy in volume number) and also identifies some publications convincingly as belonging to our respondent that would otherwise be missed, thus tending to enhance counts. In all, 3579 citations were obtained.

[16] The resulting total count of 17173 citations was reduced largely by exclusion of SCI citations to publications not by our respondents, plus exclusion of duplicates from the SCI and SSCI searches. We also generally eliminate 1979 citations (N = 25).

[17] Weighting of responses does not appear helpful in estimating general effects across the science-based fields because there is no logical way to weight the fields to represent all of the doctorate holders. See Note 6 also.

[18] For these 6 measures for the 6 fields, the average absolute difference in ranks was 0.7. Magnitudes tended to correspond well - even for the one variable - % married at doctorate - which showed poor ranking agreement (the NRC range was from 72.0% married in physics to 79.3% in electrical engineering; we ranged from 71.7% in sociology to 84.5% in physics). The one striking discrepancy is in % female in zoology where we have 2.4% while the population estimate is 15.8% (for the other 5 fields we average within 0.8% of the NRC value). The explanation appears to lie in a compounding of small sample deviations: the population drifted considerably - down to 9.1% in an NRC calendar 1970 year estimate; our address search yielded a discrepancy, based on a tally of probable sex according to first name, whereby those mailed included 4.8% women while those not sent included 14.3%; and then our women responded slightly below that 4.8% rate. We drew on several NRC sources for these data, including unpublished elaborations. The main sources were the Annual Summaries.

[19] The "other" group may appear low because of foreign persons for whom foreign language publications would be underestimated in SCI/SSCI. Also, however, the persons for whom adequate addresses were not obtained could publish less and, correspondingly, be less involved with scientific entities apt to generate current addresses (e.g., we drew on faculty and professional society registers).

[20]Charles Andersen of the American Council on Education kindly provided us with the explicit scale scores on rated quality of the graduate faculty for departments in our six fields from A Rating of Graduate Programs by K. D. Roose and C. J. Andersen (Washington, D.C., 1970). He recommended that measure over the rated effectiveness of doctoral programs as highly correlated but more valid.

[21]D.C. Spriestersbach, "The Place of the Dissertation in the Training of Graduate Students," Proceedings of the Tenth Annual Meeting of the Council of Graduate Schools in the U.S., Dec. 2-4, 1970, Miami Beach, p. 139.

[22]University of Michigan, Dissertation Review Committee of the Rackham School of Graduate Studies, The Role of the Dissertation in Doctoral Education at the University of Michigan, Ann Arbor, July, 1976, Summary report, p. 13.

[23]Hindsight may be influencing these judgments, but it is notable that reported research aim correlates only about .3 with measures of career research orientation (publications, research as a primary activity). In probing research aim, we were intrigued by the observation that 139 of 616 (22.6%) respondents indicated a high (4 or 5) career research orientation in seeking the PhD, yet were not actively engaged in research (fewer than 3 publications after 1972). Upon further investigation however, the number who seem to have abandoned research at the end of graduate training (as measured by 10% or less time spent on research in their first post-PhD job) was small (42). Only one, of a number of factors scanned, related to this departure from a research-orientation - the presence of conflict among the respondent, dissertation supervisor, and committee.

[24]Spriestersbach, p. 140; see Note 21.

[25]B. Berelson, Graduate Education in the United States, New York: McGraw-Hill, 1960.

[26]Spriestersbach, p. 141, see Note 21; quoting Flexner in the second phrase.

[27]B. R. Worthen and A. L. Roaden, The Research Assistantship: Recommendations for Colleges and Universities, Phi Delta Kappa, Inc., 1975, p. 80.

[28]F. Bowers, On a Future for Graduate Studies, AAUP Bulletin, Winter, 1970, p. 367.

[29]F. A. Rossini, A. L. Porter, D. E. Chubin, T. Connolly, and K. V. Anderson in "Crossdisciplinarity in the Biomedical Sciences: A Preliminary Analysis of Anatomy Departments," (paper presented at the American Association for the Advancement of Science Annual Meeting, 1981, Toronto) infer that the biomedical sciences have become routinely interdisciplinary in their research, but not their teaching. Also see K. E. Studer and D. E. Chubin, The Cancer Mission: Social Contexts of Biomedical Research, Beverly Hills: Sage, 1980, chapter 2 and epilogue.

[30]L. L. Hargens and G. M. Farr, "An Examination of Recent Hypotheses about Institutional Inbreeding," American Journal of Sociology 78, 1381-1402, 1973.

[31]Interestingly, in an analysis of variance of the importance of a particular faculty member in the selection of a PhD program (a 1-5 scaled rating) by field, sex, and departmental rating, all three main effects are significant (classical design, Statistical Package for the Social Sciences - SPSS). Particular faculty are a more compelling factor for zoologists (adjusted $\bar{X}$ = 3.65) and less for the sociologists (2.35), physicists (2.22), and psychologists (2.18) - with electrical engineers (2.99) and biochemists

(2.79) in-between. Women (adjusted $\bar{X} = 2.26$) weigh individual faculty less than do men (2.80) on average.

[32]Porter and Wolfle, see Note 1.

[33]Statistical "significance" should not be overstated. The tests employed for these, and similar tabulations, were analyses of variance - ANOVA - computed classically for field, sex, and Roose-Andersen ratings. Main effects were thus corrected for each other. The underlying metric for these variables is ordinal, not interval; for many the distribution is not only discrete, but asymmetric - not "normal." The F test significance levels observed were those produced by SPSS Version 7.0 (in some instances Version 8.0). Because of violations in the ANOVA assumptions, the significance levels are only indicative.

[34]Unfortunately, we did not specifically inquire as to current work sector. One indicator used was whether the respondent denoted an academic year salary base; the other was percentage of FTE employment spent in academia truncated to consider those with no more than 31% as non-academic and those with 70% or more as academic. Both yielded ANOVA main effects significant at less than .01.

[35]Porter and Wolfle, see Note 1.

[36]Means and standard deviations were all quite similar; means fell within about ±0.5 of 3.7 (on 1-5 scales) and standard deviations fell within about ±0.3 of 1.0.

[37]Our estimates reasonably corroborate the University of Michigan study (Note 22) faculty estimates, which were lower than alumni reports on the amount of dissertation research reaching publication. They rationalize the discrepancy by noting that faculty may be unaware of some later

publication while publishing alumni may be over-represented in the survey response. The values reported are (faculty estimate first, followed by alumni reports): life sciences - 65%/80%; physical sciences - 65%/78%; and social sciences - 36%/71%. These compare with our averages of percent publishing directly from the dissertation research: biochemistry and zoology - 66.4%; physics - 60.2%; and psychology and sociology - 27.8%.

[38]Values cited by G. B. Davis and C. A. Parker, Writing the Doctoral Dissertation, Woodbury, NY: Barron's Educational Series, Inc., 1979, pp. 116-117 based on Julie L. Moore, "Bibliographic Control of American Doctoral Dissertation," Special Libraries, June, 1972, p. 289.

[39]Following Porter and Wolfle (Note 1), we tally citations to each publication divided by (1978 - year of publication), with all years prior to 1969 set equal to 1969 since our citations are counted from 1970 through 1978 (1978 publications are excluded from this measure).

[40]This pattern holds very closely for citations, citations/year, and the logarithms of these measures.

[41]Classical ANOVA used (SPSS) with field and category as main effects.

[42]If citations to all "publications" (presentations, theses, technical reports, abstracts, and miscellaneous - as well as articles, books, chapters, and proceedings) are included, results show the identical pattern. Present analyses do not exclude self-citations which would be more likely to inflate the counts of earlier (i.e., dissertation-related) than later publications. However, Porter and Wolfle (Note 1) did exclude self-citations and found a similar pattern for 1963-64 psychology PhD's publications.

[43] F. A. Rossini, et al., see Note 29.

[44] These parametric statistics assume interval scaling, whereas we have 1-5 ordinal scales. The results are best considered indicative rather than definitive, but seem most suitable for present data explorations.

[45] Interdisciplinary research premises and promises are explored in R. T. Barth and R. Steck, Interdisciplinary Research Groups: Their Management and Organization, 1979 (available from D. R. Baldwin, Grant and Contract Services, University of Washington, Seattle); see also D. E. Chubin, T. Connolly, A. L. Porter, and F. A. Rossini, Interdisciplinary Research: A Primer, in preparation for Iowa State University Press.

[46] The more obvious measure, specialty area of dissertation, is inappropriate because most clinicians identify their dissertation in another area (e.g., social psychology).

[47] Dissertation Review Committee, Horace H. Rackham School of Graduate Studies, The Role of the Dissertation in Doctoral Education at the University of Michigan, University of Michigan, Ann Arbor, 1976, p. 22 of summary.

[48] ANOVA was conducted for field differences - significant on all of these variables except for positive findings and relevance. Student-Newman-Keuls multiple range test was used to ascertain if fields differed from each other by constructing homogeneous subsets. The interesting splits appeared on increasing standards (biochemistry at 3.46 and zoology at 3.17 stood apart from the others - with psychology lowest at 2.80, non-significantly different), small scale research exercises (psychology a less negative subgroup unto itself at 2.63) and extended practicum or internship with psychology (2.54), electrical engineering (2.27), and sociology (2.23) forming the less negative subgroup.

[49] Current primary work activity is coded (1) = research or research and teaching, (2) = teaching, and (3) = professional service, administration, or other [development and no responses are excluded].

[50] The nominal emphasis on research expected for non-clinical psychologists is not really there. Current primary work activity for "lab" psychologists shows 26.1% research, 39.1% teaching, and 34.8% professional; for "non-lab": 15.0%, 45.0%, and 40%; for clinical: 14.3%, 4.8%, and 81.0%.

[51] The University of Michigan study (see Note 22), in some contrast, reported that alumni found as follows: dissertation directly relevant and essential to career - 25%; directly relevant, non-essential - 30%; relevant in general - 38%; not relevant - 5%; don't know - 2% (p. 17 of summary).

[52] Porter and Wolfle, see Note 1.

[53] For a discussion of the inherent dangers see A. L. Porter, T. Connolly, R. G. Heikes, and C. Y. Park, "Misleading Indicators: The Limitations of Multiple Regression in Formulation of Policy Recommendations," Policy Sciences, Vol. 13, 397-418, 1981.

[54] This is true both for the patterns of association with the independent variables, as per Table 12 and underlying data, and for the correlation among these measures - perceived research value correlates .20 with log of publications and .15 with log of citations but .38 with training value and .44 with general affect. In comparison log publications correlates .61 with log citations, and general affect .63 with training value.

[55] The questionnaire itself (Appendix A) reflects a range of possible influences from demographic factors through graduate training choices and characteristics. Inclusion in the regressions reflects a combination of logical selection (e.g., which of the variables could be amenable to policy-

maker influence) and pre-screening based on correlation coefficients (generally non-associated variables were left out, e.g., sex).

[56] Of course it must be recollected that the perceptual measures and most of the independent variables are based on 1-5 ordinally scaled items collected via the same questionnaire.

[57] Trying not to belabor this, but we should not forget that the questionnaire is retrospective and there is always the danger of dissonance-reducing biases in responding. The reader may wish to review the survey instrument to form an opinion on the likely severity of this; we feel it is not apt to be a strong force on the assessments reflected in Tables 12 and 13.

[58] Yet, Roose-Andersen rating correlates positively (.36) with a selection criterion of departmental reputation.

[59] For our respondents' supervisors the estimated number of dissertations guided to completion is rather large - mean of 12.54; median, 6.18.

[60] There were 4 possibilities (4 separate regressions) for a field to deviate from the others on a given variable. If it did so on 3 of those 4 opportunities to a large degree, this was tallied as "1." If it did so on 1 of those to a large degree and 3 to a moderate degree, this was also tallied as 1. A scale was constructed to indicate lesser degrees of evidence of deviation with, for example, 1 large and 2 moderate deviations tallied as .7, 1 large and 1 moderate as .5, 2 moderate or 1 large as .4, and 1 moderate as .2.

This is a relative measure on an arbitrary scale for a restricted set of indicators and certainly should not be taken as definitive.

[61] See Note 1.

[62] E. Shils, "Centre and Periphery," pp. 117-130 in The Logic of Personal Knowledge: Essays Presented to Michael Polanyi on his Seventieth Birthday, London: Routledge, 1961.

[63] B. Berelson, Graduate Education in the United States, New York: McGraw-Hill, 1960.

[64] D. Crane, "Scientists at Major and Minor Universities: A Study of Productivity and Recognition," American Sociological Review 30, October, 1965, 699-714.

[65] K. D. Roose and C. J. Andersen, A Rating of Graduate Programs, Washington, D.C.: American Council on Education, 1970.

[66] B. F. Reskin, "Academic Sponsorship and Scientists' Careers," Sociology of Education 52, July 1979, 129-146.

[67] R. K. Merton, "The Matthew Effect in Science," Science 159, 5 January 1968, 56-63; H. Zuckerman, Scientific Elite: Nobel Laureates in the United States, New York, Free Press, 1977.

[68] J. K. Folger, H. S. Astin and A. E. Bayer, Human Resources and Higher Education, New York: Russell Sage, 1970; J. R. Cole and S. Cole, Social Stratification in Science, Chicago: University of Chicago Press, 1973; I. I. Mitroff and R. H. Kilmann, Methodological Approaches in the Social Sciences, San Francisco: Jossey-Bass, 1978; S. P. Turner and D. E. Chubin, "Chance and Eminence in Science: Ecclesiastes II," Social Science Information 18, 1979, 437-449.

[69] L. R. Harmon, Profiles of Ph.D.s in the Sciences: Summary Report on the Follow-Up of Doctorate Cohorts, 1935-60, Washington, D.C.: National Academy of Sciences, National Research Council, Publication #1293, 1965;

L. L. Hargens, "Patterns of Mobility of New Ph.D.s among American Academic Institutions," Sociology of Education 42, Winter 1969, 18-37.

[70] L. L. Hargens and W. O. Hagstrom, "Sponsored and Contest Mobility of American Academic Scientists," Sociology of Education 40, Winter 1967, 24-38.

[71] H. Zuckerman and R. K. Merton, "Age, Aging, and Age Structure in Science," pp. 292-356 in M. W. Riley et al. (eds.), A Theory of Age Stratification, Vol. 3, Aging and Society, New York: Russell Sage, 1972.

[72] J. F. Marsh, Jr. and F. P. Stafford, "The Effects of Values on Pecuniary Behavior: The Case of Academicians," American Sociological Review 32, October 1967, 740-754.

[73] Note that (i) SPSS's listwise deletion option was used, thereby reducing the n in each subset, and (ii) what is reported in Table B are not the most "efficient" equations in that all seven of the predictor variables were allowed to enter, though three or fewer of these variables "survived" with a significant F in any equation. Only these surviving predictors appear in Table 16.

[74] Only 37 or 5 percent of the 645 cohort members experienced the opposite conflict in career expectations, namely, that induced by a low priority on research, but publication productivity ($n \geq 3$) suggests a research orientation. This small n precludes separate analysis.

[75] Approximately 20 percent of the cohort spent less than 1 FTE year of their first decade of professional work in nonacademic settings. We explore this contextual difference for one field below.

[76]The salary surrogate for stature is not reported in Table 17 because it is virtually uncorrelated with the other dependent measures.

[77]D. C. Pelz and F. M. Andrews, Scientists in Organizations: Productive Climates for Research and Development, Revised edition, Ann Arbor, Mich.: Institute for Social Research, University of Michigan, 1976.

[78]J. Gaston, Originality and Competition in Science, Chicago: University of Chicago Press, 1973.

[79]B. F. Reskin, "Scientific Productivity, Sex, and Location in the Institution of Science," American Journal of Sociology 83, 1978, 1235-1243.

[80]R. D. Whitley, "The Sociology of Scientific Work and the History of Scientific Developments," pp. 21-50 in S. S. Blume (ed.), Perspectives in the Sociology of Science, New York: Wiley, 1977.

[81]See Merton, Note 67.

[82]See Note 1

[83]J. S. Long, P. D. Allison, R. McGinnis, "Entrance into the Academic Career," American Sociological Review 44, October 1979, pp. 816-830.

[84]See A. L. Porter, T. Connolly, and D. E. Chubin, "The Doctorate Plus a Decade," American Psychologist, to be submitted, for elaboration of the differences; they are partly (but only partly) explainable by sampling differences.

APPENDIX A

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 (404) 894-2300

March 2, 1979

Dear Colleague,

We would like your help in a study of the role of the Ph.D dissertation in the professional career--its importance as a source of scientific knowledge, as a way of learning how to perform research, and as a requirement in earning the Ph.D. We are sending this questionnaire to you and to only 150 of your colleagues who earned the doctorate in Physics in 1969-1970, and to similar samples in five other fields. Hence, we need every response in order to have significant results. This study is partially supported by a grant from the National Science Foundation.

We are particularly interested in the perspectives of those of you who may not have chosen a career path emphasizing research. We would very much like to know how the dissertation has contributed to your professional career. Naturally, we are also interested in careers that have emphasized research.

On the first page we ask you to check some information we have compiled, and to add to it as appropriate. The disposable loose sheet defines some terms commonly used in the questionnaire and lists areas of specialization for use in certain questions. The rest of the items ask about your experiences, your assessment of those experiences, and your recommendations concerning doctoral training. We hope this information will provide policy guidance to those directing doctoral training.

We recognize the difficulty in recalling specific events and relating personal experiences, and that the dissertation means different things to those pursuing various careers in diverse fields. While we have carefully field tested the questionnaire, we welcome your amplifications and comments wherever appropriate.

Although this questionnaire is not anonymous, all information will be carefully guarded so that no results will in any way be identified with individuals.

To show our appreciation for your help, we will gladly send you a copy of our findings; just check the boxes at the end of the questionnaire. We appreciate your help and trust that the results will serve our concern and yours for quality doctoral training.

Sincerely,

Alan L. Porter
Associate Professor

Daryl E. Chubin
Assistant Professor

ALP/DEC:gt

P.S. Please return to Alan L. Porter, Georgia Tech, Atlanta, GA 30332 in the enclosed postage-paid envelope.

[SAMPLE]

PHD QUESTIONNAIRE

WE HAVE GATHERED THE FOLLOWING INFORMATION FROM LIBRARY SOURCES, NAMELY, DISSERTATION ABSTRACTS AND THE SCIENCE CITATION INDEX. WE WOULD APPRECIATE YOUR CHECKING ITS ACCURACY. PLEASE MAKE ANY CORRECTIONS ON THIS PAGE.

WE EMPHASIZE THAT THIS INFORMATION WILL NEVER BE ATTRIBUTED BY INDIVIDUAL OR INDIVIDUAL SCHOOL. WE NEED NAME IDENTIFICATION TO FOLLOW POST-GRADUATION CAREER ACTIVITIES.

NAME: SMITH S. S. PHD FIELD: SOLID STATE PHYSICS

YEAR OF DOCTORAL DEGREE: 1969 INSTITUTION: DUKE

PLEASE INDICATE THE FOLLOWING INFORMATION FOR EACH OF YOUR PROFESSIONAL PUBLICATIONS. (PLEASE ADD ANY ARTICLES, BOOKS, OR MONOGRAPHS WE HAVE MISSED, NOTING THE AUTHORS AND SOURCE INFORMATION.)

-UNDER "CATEGORY" PLEASE CATEGORIZE EACH PUBLICATION AS:
1) PRE-DISSERTATION RESEARCH
2) DIRECTLY TAKEN FROM YOUR DISSERTATION RESEARCH
3) RESULTING FROM CONTINUATION OF THE DISSERTATION RESEARCH
4) OTHER POST-PHD WORK NOT DIRECTLY ASSOCIATED WITH THE DISSERTATION

-UNDER "SCALE OF EFFORT" PLEASE ESTIMATE THE TOTAL WORK INVESTED IN EACH PIECE, BY ALL AUTHORS, AS FOLLOWS:
1) LESS THAN TWO MONTHS (FULL TIME EQUIVALENT--FTE)
2) TWO TO SIX MONTHS (FTE)
3) GREATER THAN SIX MONTHS (FTE)

AUTHORSHIP			SOURCE					
ST AUTHOR		MULTIPLE AUTHORS?	TITLE	VOLUME	PAGE	YEAR	CATEGORY	SCALE OF EFFORT
ES	QQ	YES	PHYS REV	1	298	75		

NOTE: Many items request a response on a 5-point scale. A description of the end points is always given; values "2," "3," and "4" are to be taken as intermediate values. "NA" indicates "not applicable," for whatever reason. When any question does not suitably reflect your experience, please describe that experience under "comment" or "other," or at the end of the questionnaire.

Items generally pertain to your experiences; those requesting your opinions appear in *italics*.

1. Demographic Information . . . . Sex: Male ___ Female ___ *a*
Year of Birth . . 19___ *b*

Family responsibility during the year prior to receipt of PhD:

-Marital Status (1=never married, 2=married, 3=other-- e.g., divorced, widowed, separated) . . . . ___ *c*

-Total No. of dependents other than yourself . . . . ___ *d*

2. Post-Secondary Degrees Other Than the PhD

Degree (e.g., B.S., M.A., LL.D.)	Institution	Field (Please use Code No. from the enclosed Specialties List)	Year of Degree	
___	___	___	___	*a-d*
___	___	___	___	*e-h*
___	___	___	___	*i-l*

3. We are interested in the time you spent in doctoral training, including actual (calendar) and full-time equivalent (FTE) time estimates.

About how many FTE months did you devote to your doctoral program in total (e.g., include time as a graduate assistant or such)? . . . . ___ (FTE mo) *a*

When did you begin to work on dissertation research or possible dissertation research? [Please indicate most appropriate category.] . . . ___ *b*

1) In the early stages of course work for the doctorate
2) In the middle stages of course work for the doctorate
3) In the later stages of course work for the doctorate
4) After course work, before "candidacy" (i.e., passing comprehensive exams)
5) After "candidacy"

-In your opinion when do you think doctoral students should begin to work on dissertation research in your field? [Please use the above scale.] . . . . ___ *c*

About how many calendar months elapsed while working on your dissertation (e.g., from time of approval of the dissertation proposal to completion)? ___(cal. mo) *d*

About how many FTE months did you spend working on the dissertation per se? ___ (FTE mo) *e*

	Too Short		About Right		Too Long	
-How would you characterize this?	1	2	3	4	5	*f*

Please estimate [in the first column] the percentage of time you spent on the various aspects of your dissertation and [in the second column] the "ideal" amount of time that ought to be spent on each aspect in your area of study.

	% You Spent	*"Ideal" %*	
-problem formulation/conceptual or theoretical development	___	___	*g-h*
-equipment preparation	___	___	*i-j*
-data gathering	___	___	*k-l*
-data analysis	___	___	*m-n*
-writing	___	___	*o-p*
-other (please specify) ___	___	___	*q-r*
	[SUM=100%]	[SUM=100%]	

Comments?

8

4. Which of the following sources provided the largest portion of your financial support during the period of your dissertation research? . . . . ___ (Primary) *a*
   -If a second source provided substantial support, please indicate . . . ___ (Secondary) *b*

   -Which source provided the largest portion of your support during the writing of the dissertation? . . . . ___ (Primary) *c*
   -If a second source provided substantial support, please indicate . . . ___ (Secondary) *d*

   1) Fellowship
   2) Research assistantship
   3) Teaching fellowship or assistantship
   4) Other part-time employment
   5) Full-time employment
   6) Loan
   7) Spouse's earnings
   8) Assistance from other family members
   9) Other (please specify) ________________

   -To what extent was your paid employment (if any) during the dissertation research period related to the dissertation itself? . . . . . — Not At All / Very Much: NA 1 2 3 4 5 *e*

   -Was some form of federal fellowship or traineeship instrumental to your pursuit of the doctorate? . . . . Yes ___ No ___ *f*

   -Was some form of federal research grant support (e.g., to yourself, supervisor, or committee member) instrumental to your dissertation work? . Yes ___ No ___ *g*

5. How important were the following career aims in your decision to seek a PhD?

	Not Important				Very Important	
-To prepare for a research-oriented career	1	2	3	4	5	*a*
-To prepare for a teaching career at the college (university) level . .	1	2	3	4	5	*b*
-To prepare for other professional practice	1	2	3	4	5	*c*
-Other (please specify) ________________	NA 1	2	3	4	5	*d*

Comments? *e*

6. How important were the following factors in your selection of a particular PhD program?

	Not Important				Very Important
-General reputation of the university	1	2	3	4	5
-General reputation of the department (institute, program, etc.)	1	2	3	4	5
-Specific reputation of the strength in your intended specialty area (e.g., eminent faculty, particular lab facilities)	1	2	3	4	5
-Intent to do your dissertation research with a certain faculty member .	1	2	3	4	5
-Availability of financial support	1	2	3	4	5
-Situational factors (e.g., geographic location, familiarity, special opportunity, spouse's career opportunities)	1	2	3	4	5

Comments?

7. How important were the following factors in your choice of a dissertation topic?

	Not Important				Very Important
-Scientifically important topic to which you could make a real contribution	1	2	3	4	5
-Special inherent interest in the topic (personally meaningful)	1	2	3	4	5
-Need for a manageable study to fulfill the dissertation requirements within a reasonable time frame	1	2	3	4	5
-Faculty (supervisor) preference	1	2	3	4	5
-Environmental considerations, such as availability of financial assistance, lab facilities, etc.	1	2	3	4	5

Comments?

What is the specialty area of your dissertation? . . . . ___
[Please use code number from the enclosed Specialties List.]

8\. How important were the following in the evaluation of your dissertation?

	Not Important				Very Important	
-Originality (no similar prior work)	1	2	3	4	5	*a*
-Findings that constituted a significant contribution to scientific knowledge	1	2	3	4	5	*b*
-Positive (rather than negative) findings (e.g., confirmation rather than rejection of hypotheses, or statistically significant findings). .	1	2	3	4	5	*c*
-Relevance of findings to practical applications	1	2	3	4	5	*d*
-Explicit demonstration of your competence to do research in the field .	1	2	3	4	5	*e*

Comments? *f*

9\. How would you characterize your dissertation on the following dimensions? Please indicate your responses on 1-5 scales where "3" indicates a balance between the emphases.

-Theoretical (1) vs. Empirical/Experimental (5)	NA	1	2	3	4	5	*a*
-Laboratory (1) vs. Field (5)	NA	1	2	3	4	5	*b*
-Individual (1) vs. Collaborative (i.e., the dissertation entailed cooperative effort with colleagues, possibly as part of a group project; "3" could indicate partial collaboration, such as having someone perform laboratory analyses) (5)	NA	1	2	3	4	5	*c*
-Basic (1) vs. Applied (5)	NA	1	2	3	4	5	*d*

Comments? *e*

10\. We are particularly interested in the role played by your dissertation supervisor and committee.

Who was your main dissertation supervisor? ______ ________________ (Last name) ______________ (First) ______ (Initial) *a-c*

What was his or her academic rank at the time of your dissertation research? . . . . ________________ *d*

Was this person also your committee chairperson? . . . . Yes ___ No ___ *e*

At the time of your dissertation how prominent was your supervisor within his or her area of specialization? (Consider such factors as esteem of immediate and distant colleagues, publications, and formal professional recognition.) . . . . ___ *f*

1) Renowned (i.e., among the top 5% nationally active in this area of specialization)
2) Eminent (i.e., among the top 20% nationally)
3) Established
4) Not prominent

At the time of your dissertation, how many other dissertations would you estimate your supervisor had guided to completion? . . . . ___ *g*

-How many were in process concurrently with your own? . . . . ___ *h*

Which one of the following best characterizes the supervision provided

-by your dissertation supervisor . . . . ___ *i*

-by other members of your committee . . . . ___ *j*

1) Minimal throughout the study
2) Significant at the completion of the dissertation
3) Significant at the initial prospectus and final stages
4) Moderate throughout
5) Heavy throughout (for the committee query - frequent significant interaction with 1 or more members)
6) Almost daily

During your dissertation were there any serious conflicts		No Serious Conflict				Very Serious Conflict	
-between you and your supervisor?	NA	1	2	3	4	5	*k*
-between you and other committee members?	NA	1	2	3	4	5	*l*
-among committee members (including supervisor)?	NA	1	2	3	4	5	*m*

To what extent were you inspired or stimulated by — Not At All / Very Much

- -your supervisor . . . . NA 1 2 3 4 5 *n*
- -other committee members . . . . NA 1 2 3 4 5 *o*

Did you co-author any publications with your supervisor? . . . . Yes____ No ____ *p*

How important was your supervisor in helping you obtain your first post-PhD job? . . . . Not At All / Very Important NA 1 2 3 4 5 *q*

Please note any other characteristics of the supervision you received that affected the value of your dissertation experience. *r*

11. How helpful were the following in your dissertation work/ doctoral training? — Not At All / Very Helpful

- -Seminars, research group meetings, or student colloquia . . . . NA 1 2 3 4 5 *a*
- —Research advice and assistance from graduate students . . . . NA 1 2 3 4 5 *b*
- -Research advice and assistance from other professionals (e.g., faculty other than committee members, post-doctoral personnel, senior research staff) . . . . NA 1 2 3 4 5 *c*
- -Research assistance from technicians and non-professionals . . . . . . NA 1 2 3 4 5 *d*

How would you rate the overall adequacy of the research facilities available to you during your dissertation research? . . . . — Not Satisfactory / Very Satisfactory NA 1 2 3 4 5 *e*

- -For sake of comparison, how would you rate the overall adequacy of your current research facilities? . . . . NA 1 2 3 4 5 *f*

Comments? *g*

12. To what extent did you carry forward your dissertation work after completion of the doctorate? . . . . — Not At All / Very Much NA 1 2 3 4 5 *a*

- -If not, would you have preferred to carry it forward had there been support to do so (e.g., a post-doctoral fellowship)? . . . . NA 1 2 3 4 5 *b*

Comments? *c*

13. How would you evaluate your dissertation experience in terms of: — Not Satisfactory / Very Satisfactory

- -yielding valuable research findings in its own right . . . . NA 1 2 3 4 5 *a*
- -learning how to perform independent research in general . . . . NA 1 2 3 4 5 *b*
- -learning specific research skills that have proved relevant to your later work . . . . NA 1 2 3 4 5
- -learning to write effectively for scholarly publication . . . . NA 1 2 3 4 5
- -learning other professional (non-research) skills you now find valuable . . . . NA 1 2 3 4 5
- -generally being a valuable experience . . . . NA 1 2 3 4 5

Comments?

14. Looking back, how satisfied are you with — Not Satisfied / Very Satisfied

- -your choice of dissertation topic? . . . . NA 1 2 3 4 5
- -the specialty area of your doctoral training? . . . . NA 1 2 3 4 5
- -the general graduate field of study you selected? . . . . NA 1 2 3 4 5
- -having earned a PhD? . . . . NA 1 2 3 4 5

Comments?

15. Since earning your doctorate, for how many full-time equivalent (FTE) years have you been employed by

-business or industry?	___ (FTE yrs)	*a*
-academic institutions?	___ (FTE yrs)	*b*
-government (federal, state, or local)?	___ (FTE yrs)	*c*
-others (e.g., self-employed)	___ (FTE yrs)	*d*

16. Have you held a post-doctoral fellowship or temporary research associateship? . . . . Yes ___ No ___ *a*

-If yes, awarded by whom? ______________________ When (year)? __________ *b–c*

-If no, to what extent would you have been interested if the opportunity arose (whether or not it did)? . . . . Not At All / Very Much: NA 1 2 3 4 5 *d*

What was (or would have been) the main reason for taking a temporary post-doctoral appointment? . . . . ___ *e*

1) Research experience
2) Switching specialty area
3) Lack of desirable permanent employment
4) Other (please specify) ______________________

17. Please consider the following questions with respect to both your job during the first year after receipt of the PhD [in the first column] and your current position [in the second column].

	First Year Post-PhD Job	Current Job	
What was/is the primary work activity involved? . . . . 1) Research 2) About equal balance of research and teaching 3) Teaching 4) Development (or design) 5) Professional service (or technical staff other than R&D) 6) Administration (management) 7) Other (please specify) __________	___	___	*a–b*
How relevant was/is your dissertation to your work activity?	Not At All / Very Much 1 2 3 4 5	Not At All / Very Much 1 2 3 4 5	*c–d*
About what percentage of your time was/is devoted to research?	___%	___%	*e–f*
What specialty best describes your <u>primary</u> <u>work</u> <u>area</u>? [Please use code number from the enclosed Specialties List.]	___	___	*g–h*
What specialty best describes your own <u>primary professional</u> <u>identification</u>? [Please use code number.]	___	___	*i–j*
Which statement best describes your level of supervisory responsibility? . . . . 1) Supervise no personnel 2) Responsible for indirect or staff supervision (no line authority) 3) Supervise students (e.g., graduate assistants) 4) Supervise team, unit, project, or section 5) Manage major department or division 6) General management of organization	___	___	*k–l*

Are you currently employed on: an academic year basis (9-10 months) ___ *m*
a calendar year basis (11-12 months) ___ *n*

-Which category best estimates your current annual income from employment and related professional activities? (<u>Include</u> salary before deductions, honoraria, consulting fees, etc.; <u>exclude</u> fringe benefits, income from investments, etc.) . . . . ___ *o*

1) Less than $4,000	5) $16,000 - $19,999	9) $32,000 - $35,999
2) $4,000 - $7,999	6) $20,000 - $23,999	10) $36,000 - $39,999
3) $8,000 - $11,999	7) $24,000 - $27,999	11) Over $40,000
4) $12,000 - $15,999	8) $28,000 - $31,999	

-About what percentage of your current annual income is from sources other than your primary salary? . . . . ___% p

Comments? q

18. *How would you rate current dissertation practices in your PhD area? (If you cannot make a judgment, indicate "NA.")*

	Too Little		About Right		Too Much	
-emphasis on originality	1	2	3	4	5	*a*
-emphasis on obtaining positive (rather than negative) research results	1	2	3	4	5	*b*
-emphasis on relevance of the dissertation to student's career needs	1	2	3	4	5	*c*

What is your opinion of the following possible changes in doctoral requirements?

	Strongly Disapprove				Strongly Approve	
-Overall increase in standards and requirements to obtain the PhD (e.g., increased coursework, publication)	1	2	3	4	5	*d*
-Several small scale, original research exercises in lieu of the dissertation	1	2	3	4	5	*e*
-Dissertation research as at present, but several short reports, more like articles, in lieu of the written dissertation as presently required	1	2	3	4	5	*f*
-Extended practicum or internship activities to acquire professional skills that are not research-oriented, in lieu of the dissertation (within a PhD program)	1	2	3	4	5	*g*
-The option of alternative doctoral degrees (e.g., Doctor of Arts, Doctor of Engineering) not oriented toward research	1	2	3	4	5	*h*

If you care to comment further, we would welcome any thoughts you might have on ways to make the dissertation more effective for research-oriented persons, ways to better accommodate doctorate-seekers not inclined toward research, needs to respond to decreased academic career opportunities for PhD's, and so on.

Please check if you would like to receive our:

-report focused on your field of specialization . . . . ___

-report comparing the 6 fields under study . . . . ___

Please return to Alan L. Porter, Georgia Tech, Atlanta, GA 30332 in the enclosed postage-paid envelope.

List of Specialty Codes

Note: This listing is more detailed in the area of Physics. Please use the code most appropriate to your item response.

Arts & Humanities

841	Art
842	History
845	Languages & Literature
843	Philosophy
846	Other/General

Engineering

400	Aeronautical & Astronautical
430	Chemical
420	Civil
435	Electrical
465	Engineering Science
450	Industrial
470	Mechanical
455	Nuclear
477	Operations Research, Systems
499	Other/General

Life Sciences

518	Agricultural Sciences
545	Anatomy
540	Biochemistry
544	Biometrics
542	Biophysics
550	Botany
546	Cytology
560	Ecology
547	Embryology
571	Entomology
570	Genetics
562	Hydrobiology
548	Immunology
538	Medical Sciences (Medicine)
564	Microbiology & Bacteriology
572	Molecular Biology
566	Physiology, Animal
567	Physiology, Plant
569	Zoology
579	Other/General

Physical Sciences/Mathematics

101	Astronomy
298	Chemistry
095	Computer Sciences
398	Earth Sciences
098	Mathematics
729	Statistics
112	Other/General

Physics

132	Acoustics
110	Atomic & Molecular
120	Electromagnetism
140	Elementary Particles
134	Fluids
130	Mechanics
150	Nuclear Structure
136	Optics
135	Plasma
160	Solid State
138	Thermal
198	Physics, General
199	Physics, Other

Professional Fields

882	Business Administration
938	Education
884	Journalism
886	Law, Jurisprudence
891	Library & Information Science
887	Social Work
885	Speech & Hearing
881	Theology
770	Urban & Regional Planning
898	Other

Social Sciences/Psychology

700	Anthropology
720	Economics
740	Geography
750	Political Science, Public Administration
601	Psychology
760	Sociology
799	Other/General

[Terminology on Back]

Terminology

<u>Committee</u>-- the faculty committee that advises and evaluates (to whatever extent) the dissertation.

<u>Dissertation</u>--the thesis prepared in partial fulfillment of the requirements for the doctorate.

-dissertation <u>experience</u>--the composite activities involved in all stages of completing the dissertation requirements, exclusive of other aspects of doctoral training (e.g., coursework, comprehensive exam).

-dissertation <u>research</u>--those activities involved in performance of the study itself, exclusive of <u>writing</u> per se.

<u>PhD</u>-- generic shorthand for doctorates, most commonly the Doctor of Philosophy, but also the Doctor of Science and the Doctor of Engineering.

<u>Supervisor</u>-- the main person guiding preparation of the dissertation, e.g., advisor, major faculty member, mentor, and/or chairperson of the committee.

[Specialties List on Back]

PhD Q Codebook

General Notes: Blanks coded blank (will appear as -0 in data file)
NA coded = 0.
Scale items for which 2 responses given, use average rounded off to odd number.
Numbers too large to fit spaces provided are entered as the highest number that fits.
Field Code appears in Col. 76 of each card.
Individual Code appears in Cols. 77-79 of each card = nnn.
Card # appears in Col. 80.
All ties between "given choice" and "other"; choose "given choice."
Numbered variables are really "Vn" (e.g., 10 is V10)

Item	Description/Code	Card-Column	Variable
	Field Code: 1 = Physics, 2 = Sociology, 3 = Zoology, 4 = EE, 5 = Biochemistry, 6 = Psychology	Each Card 76	FIELD
	Individual ID Number	Each Card 77-79	INDIV
1.a.	Sex: M = 1, F = 2	1 1	1
b.	Birth: Year = nn	2-3	2
c.	Marital Status: Never Married = 1 Married = 2 Other = 3	4	3
d.	Dependents other than self = n	5	4
2.a.	Degree: Bachelors (B.A., B.S., PHB, AB, etc.) = 1 Masters (M.A., M.S.) MSSW, MSPH, AM, MED = 2 M.B.A. = 3 J.D./LL.D. = 4 M.D., DPM = 5 Other Doctorate = 6 Theology (M.Th.) = 7 Other MSN, EE = 9	6	5
b.	Institution/Campus: NRC Numeric Code = nn - nnn - and sometimes letter [dashes not punched] (e.g., 93 440=UCB; 93 440F=UCLA) 17-111 Foreign Institution 15-111 Unlisted U.S.	7-12/13	6/7α
c.	Field: Our Numeric Code = nnn	14-16	8
d.	Year: nn	17-18	9
e.	Second Degree [codes as in 2a-d]	19	10
f.	Second Institution/Campus	20-25/26	11/12α
g.	Second Field	27-29	13
h.	Second Year	30-31	14
i.	Third Degree	32	15
j.	Third Institution/Campus	33-38/39	16/17α
k.	Third Field	40-42	18
l.	Third Year	43-44	19
3.a.	Doctoral Program - FTE months = nn [Exclude Masters Program months if separate indication given]	45-46	20
b.	Began diss. work: Early course stages = 1 Middle course stages = 2 Later course stages = 3 After courses = 4 After "candidacy" = 5	47	21
c.	Should begin diss. work [Code as 3.b.]	48	22
d.	Dissertation time elapsed - Calendar months = nn	49-50	23
e.	Dissertation - FTE months = nn	51-52	24
f.	Characterize this: Too Short = 1 to Too Long = 5	53	25
g-h.	% of time spent - ideal %: on problem formulation/conceptual development = nn, nn	54-55, 56-57	26, 27
i-j.	: on equipment preparation	58-59, 60-61	28, 29
k-l.	: on data gathering	62-63, 64-65	30, 31
m-n.	: on data analysis	66-67, 68-69	32, 33
o-p.	: on writing	70-71, 72-73	34, 35
q-r.	: on other	2 1-2, 3-4	36, 37
	[Note: Lit Review, when caught - recorded as prob. formulation]		

Item	Description/Code	Card-Column	Variab
4.a.	Financial support during diss. research: Primary Fellowship = 1 Loan = 6 Res. Asst. = 2 Spouse's earnings = 7 Teaching Fellow/Asst. = 3 Assist. from other family members = 8 Other Part-time Employ = 4 Full-time Employ = 5 Other = 9 (Note: when given secondary only, we coded as primary)	2 5	38
b.	Financial support during diss. research: Secondary	6	39
c.	Financial support during diss. writing: Primary	7	40
d.	Financial support during diss. writing: Secondary	8	41
e.	Extent paid employment related to diss.: Not at all = 1, 0 = NA Very much = 5	9	42
f.	Federal fellowship/traineeship instrumental: 1 = No 3 = Other 5 = Yes	10	43
g.	Federal grant support instrumental: 1 = No 3 = Other 5 = Yes	11	44
5.	Importance of career aims in decision to seek a PhD:		
a.	Prepare for research-oriented career: Not important = 1 Very important = 5	12	45
b.	Prepare for teaching	13	46
c.	Prepare for professional practice	14	47
d.	Other	15	48
6.	How important in selection of particular PhD program?		
a.	General reputation of university: Not important = 1 Very important = 5	16	49
b.	General reputation of dept.	17	50
c.	Specific reputation in specialty area	18	51
d.	Particular faculty member intended diss. supervisor	19	52
e.	Financial support	20	53
f.	Situational factors	21	54
7.	How important in choice of diss. topic?		
a.	Scientifically important topic to which you make real contribution: Not important = 1 Very important = 5	22	5
b.	Personal inherent interest	23	5
c.	Manageable study to fulfill requirements	24	5
d.	Faculty preference	25	5
e.	Environmental considerations	26	5
g.	Specialty area of diss.	27-29	6
8.	How important in evaluation of your diss.?		
a.	Originality: Not important = 1 Very important = 5	30	6
b.	Significant contribution to science	31	6
c.	Positive findings	32	6
d.	Practical relevance	33	6
e.	Demonstration of field competence	34	6
9.	Diss. characterized as		
a.	Theoretical (1) vs. Empirical/Experimental (5)	35	
b.	Lab (1) vs. Field (5)	36	
c.	Individual (1) vs. Collaborative (5)	37	
d.	Basic (1) vs. Applied (5)	38	
10.a.	Diss. Supervisor: last name	39-53	
b.	first name	54-63	
c.	middle initial	64	
d.	Academic rank: Professor = 1 Assoc. Prof. = 2 Asst. Prof. = 3 Lecturer/Instructor = 4 Adjunct = 5 Other = 6 Research Prof., Assoc., or Asst. Prof. = 7 Adm./Dean = 8 (not chairman) If rank changes take larger e.g.: Assoc. → Full is 1	65	

Item	Description/Code	Card-Column	Variable
e.	This person also committee chair?: Yes = 1, No = 2, Other = 3	2 66	74
f.	Diss. supervisor prominence: Renowned (top 5% nationally) = 1 Eminent (top 20% nationally) = 2 Established = 3 Not prominent = 4	67	75
g.	Other diss. guided to completion by your diss. supervisor: nn	68-69 (100=99) (Many=88)	76
h.	Other diss. concurrently in process with your diss. supervisor: nn	70-71	77
i.	Characterize supervision by your diss. supervisor: Minimal throughout = 1 Signif. at completion = 2 Signif. at initial and final stages = 3 Moderate throughout = 4 Heavy throughout = 5 Almost daily = 6	72	78
j.	Characterize supervision by other member of your committee [code as in i.]	73	79
	Any serious conflicts?		
k.	Between you and supervisor: No serious conflict = 1 Very serious conflict = 5	3 1	80
l.	Between you and other committee members	2	81
m.	Among committee members (including supervisor)	3	82
n.	Inspired or stimulated by supervisor: Not at all = 1 Very much = 5	4	83
o.	Inspired or stimulated by other committee members	5	84
p.	Co-author any publications with supervisor: 1 = No 3 = Other* 5 = Yes *unpublished but submitted/conference presentation	6	85
q.	Importance of supervisor in obtaining post-PhD job: Not at all = 1 Very important = 5	7	86
11.	How helpful in diss. work/doctoral training?		
a.	Seminars, research group meetings, student colloquia: Not at all = 1 Very helpful = 5	8	87
b.	Research advice and assistance from grad. students	9	88
c.	Research advice and assistance from other professionals	10	89
d.	Research assistance from technicians and non-professionals	11	90
e.	How rate overall adequacy of research facilities for diss.: Not satisfactory = 1 Very satisfactory = 5	12	91
f.	How rate current research facilities?	13	92
12.a.	Extent carried forward diss. work after doctorate: Not at all = 1 Very much = 5	14	93
b.	If not, preferred to had there been support?	15	94
13.	How evaluate your diss. experience:		
a.	Valuable research findings: Not satisfactory = 1 Very satisfactory = 5	16	95
b.	Learn to do independent research	17	96
c.	Learn specific research skills relevant to later work	18	97
d.	Learn to write effectively for scholarly publication	19	98
e.	Learn other professional skills now find valuable	20	99
f.	Generally being a valuable experience	21	100
14.	Looking back, how satisfied are you with		
a.	Choice of diss. topic	22	101
b.	Specialty area of doctoral training	23	102
c.	General grad. field selected	24	103
d.	Having earned a PhD	25	104

Item	Description/Code	Card-Column	Variable
15.	FTE years employed by (since PhD)		
a.	Business or industry: nn	3 26-27	105
b.	Academic institutions	28-29	106
c.	Government	30-31	107
d.	Others	32-33	108
16.a.	Held post doc fellowship or temp. res. associateship: 1 = No 3 = Other 5 = Yes (esp. short term ≤ 6 mos.)	34	109
b_1.	If yes, awarded by Federal, NIH = 11 , NIMH = 12 , NSF = 13 , AEC = 14 , VA = 15 , Federal Lab = 16 , Other Federal = 17 NRC-NAS = 21 Private Foundation = 22 Non-U.S. (e.g., university, national academy) = 23 Industrial = 31 Elite U.S. university, other than PhD grantor = 41 Other U.S. university, other than PhD grantor = 42 The PhD granting university = 43 Unclassifiable = 45	35-36	110
c_1.	Year of post doc (1st)	37-38	111
b_2.	Second post doc, awarded by	39-40	112
c_2.	Year second post doc awarded	41-42	113
d.	If no post doc, how interested if opportunity had arisen: Not at all = 1 Very much = 5	43	114
e.	What was (or would have been) reason for post doc: Research experience = 1 Switch specialty = 2 Lack of desirable permanent employment = 3 Other = 4 [if 1 and 2 code 2; if 1 or 2 and 3 code 3]	44	115
17.	Consider each first w.r.t. job first year after PhD; second w.r.t. current job:		
a-b.	Primary work activity: Research = 1 Research & Teaching = 2 Teaching = 3 Development (design) = 4 1&4 = 4 (equal Res. & Dev. = Dev.) Professional service = 5 Administration = 6 Other = 7 Admin + (Res. and/or Teach.) = [6 + 1 +/or 2 +/or 3] = 8 Other combos (3&5) and/or 4; 5 & 6 = 9	45, 46	116, 117
c-d.	How relevant diss. to work activity? Not at all = 1 Very much = 5	47, 48	118, 119
e-f.	% time for research	49-51, 52-54	120, 121
g-h.	Primary work area (specialty code)	55-57, 58-60	122, 123
i-j.	Primary professional identification	61-63, 64-66	124, 125
k-l.	Supervisory responsibility: No personnel = 1 Indirect or staff supervisor = 2 Students = 3 } for 3 & 4 combo Team, unit, project, or section = 4 } pick 4 Major department or division = 5 General management = 6 Note: Go to larger in all cases	67, 68	126, 127
m or n.	Employed: academic year basis = 1 calendar year basis = 2	69	128 (exclude summer i academic checked)

Item	Description/Code	Card-Column	Variable
o.	Current professional income: < \$4000 = 01 24000-27999 = 07 4000-7999 = 02 28000-31999 = 08 8000-11999 = 03 32000-35999 = 09 12000-15999 = 04 36000-39999 = 10 16000-19999 = 05 > 40000 = 11 20000-23999 = 06	3 70-71	129
p.	% of income from sources other than primary salary = nn	4 1-2	130
18.	Rate current diss. practices in your PhD area: too little = 1 too much = 3		
a.	Emphasis on originality	3	131
b.	Emphasis on positive results	4	132
c.	Emphasis on relevance	5	133
	Opinion of possible changes in doctoral requirements: strongly disapprove = 1 strongly approve = 5		
d.	Increase standards and requirements	6	134
e.	Several small scale research exercises	7	135
f.	Several short reports of research	8	136
g.	Practicum in lieu of diss.	9	137
h.	Alternative doctoral degrees not research-oriented	10	138
	Want report on your field: Yes = 1	11	139
	Want report comparing the 6 fields: Yes = 1	12	140

Description	Format	Variable Name
Total articles, books, chapters, proceedings,		
(PT = 1,2,3,4) CTGY = 1	F3.0	PUCE
" " " " " CTGY = 2	F3.0	PUCF
" " " " " CTGY = 3	F3.0	PUCG
" " " " " CTGY = 4	F3.0	PUCH
"Pubs" other than articles, books, chapters, proceedings,		
(PT = 5,6,7,8,9,0); CTGY = 1	F3.0	PUCI
" " " " " CTGY = 2	F3.0	PUCJ
" " " " " CTGY = 3	F3.0	PUCK
" " " " " CTGY = 4	F3.0	PUCL
Weighted pubs by effort (P3 = 1)	F3.0	P31
" " " (P3 = 2)	F3.0	P32
" " " (P3 = 3)	F3.0	P33
" " " (P3 = 4)	F3.0	P34
" " " (P3 = 5)	F3.0	P35
" " " (P3 = 6)	F3.0	P36
PYR = 1 for PYEAR 1 thru 62		
= 2 " " 63 " 66		
= 3 " " 67 " 68		
= 4 " " 69 " 72		
= 5 " " 73 " 74		
= 6 " " 75 " 80		
Total articles (PT = 1), PYR = 1	F3.0	PUYA
" " " PYR = 2	F3.0	PUYB
" " " PYR = 3	F3.0	PUYC
" " " PYR = 4	F3.0	PUYD
" " " PYR = 5	F3.0	PUYE
" " " PYR = 6	F3.0	PUYF
Total articles, books, chapters, proceedings		
(PT = 1,2,3,4), PYR = 1	F3.0	PUYG
" " " PYR = 2	F3.0	PUYH
" " " PYR = 3	F3.0	PUYI
" " " PYR = 4	F3.0	PUYJ
" " " PYR = 5	F3.0	PUYK
" " " PYR = 6	F3.0	PUYL
other pubs not articles, books, chapters, or proceedings		
(PT = 5,6,7,8,9,0), PYR = 1	F3.0	PUYM
" " " PYR = 2	F3.0	PUYN
" " " PYR = 3	F3.0	PUYO
" " " PYR = 4	F3.0	PUYP
" " " PYR = 5	F3.0	PUYQ
" " " PYR = 6	F3.0	PUYR
Citation Information		
Number of citations - non self cite in the year 1970	F3.0	VV1
" " " - self cite " " " 1970	F3.0	VV2
" " " - not known if self cite or not " " " 1970	F3.0	VV3
" " " - non self cite " " " 1971	F3.0	VV4
" " " - self cite " " " 1971	F3.0	VV5
" " " - not known if self cite or not " " " 1971	F3.0	VV6
" " " - non self cite " " " 1972	F3.0	VV7
" " " - self cite " " " 1972	F3.0	VV8
" " " - not known if self cite or not " " " 1972	F3.0	VV9
" " " - non self cite " " " 1973	F3.0	VV10
" " " - self cite " " " 1973	F3.0	VV11
" " " - not known if self cite or not " " " 1973	F3.0	VV12
" " " - non self cite " " " 1974	F3.0	VV13
" " " - self cite " " " 1974	F3.0	VV14
" " " - not known if self cite or not " " " 1974	F3.0	VV15
" " " - non self cite " " " 1975	F3.0	VV16
" " " - self cite " " " 1975	F3.0	VV17
" " " - not known if self cite or not " " " 1975	F3.0	VV18
" " " - non self cite " " " 1976	F3.0	VV19
" " " - self cite " " " 1976	F3.0	VV20
" " " - not known if self cite or not " " " 1976	F3.0	VV21
" " " - non self cite " " " 1977	F3.0	VV22
" " " - self cite " " " 1977	F3.0	VV23
" " " - not known if self cite or not " " " 1977	F3.0	VV24
" " " - non self cite " " " 1978	F3.0	VV25
" " " - self cite " " " 1978	F3.0	VV26
" " " - not known if self cite or not " " " 1978	F3.0	VV27
" " " - non self cite " " " 1979	F3.0	VV28
" " " - self cite " " " 1979	F3.0	VV29
" " " - not known if self cite or not " " " 1979	F3.0	VV30
Total N of all citations for 1970-79	F5.0	TOTN

PUBLICATION FILE

Description	Format	Variable Name
Variables on Publications from New Survey Respondents		
Publication field	F1.0	PF
Person identification number	F3.0	PID
Publication number	F4.0	PN
Publication respondent - 4 letters	A4	PR
Publication First Author Last Name	A9	PFA
Publication First Author Initials	H2	PFAI
Multiple Authorship 1 = Single 2 = Multiple	F1.0	PM
Journal Name	A10	PJ
Volume	A5	PV
Page	A5	PP
Publication Year 1=≤62, 2=63-66, 3=67,68, 4=69-72 5=73-74, 6=≥75	F2.0	PYR
Type of publication (see below)	F1.0	PT=1 if TYPE=1 2 if TYPE=1,2,3, 9 if TYPE=Other
Same as VV1-VV30 in BIGQF (see "PhD Q Codebook")	F2.0 F5.0	VI-V30 TOTN
Variables from Old Psychologist File		
Order of Authorship 1 = First author (is our respondent) 0 = Not first author	F1.0	GCODE
Publication year	F2.0	GYR
Months of effort invested in the article	F5.1	GMO
See "Index to Variables in BIGOQ"	F2.0	GSC64 -GTC72
Combined Variables		
Category 1 = Pre-Dissertation 2 = Directly from Diss. 3 = Continuation of Diss. work 4 = Post PhD, non-Diss. related	F4.2	CTGY*
Effort recorded (from PS & GMO) to 1. <2 mos. FTE 2. 2-6 Mos. FTE 3. > 6 Mos. FTE	F5.2	SCALE*
Type of Publication (1) Article (2) Book (3) Bk Chapter (4) Proceedings (5) Presentations at meetings (6) Diss. (7) Tech Reports (8) Abstracts (9) Masters Thesis (0) Misc. (Newsletters)	F3.1	PTYPE*
Year of Publication (e.g. -69,70,71 vs. PYR 'coded')	F4.0	PYEAR*
Original Pub Type coded as 1,2,...,0	F2.0	PTORG
P2=1 if PT=1,2 (orig. Pub. Type 1,2,3,4)	F2.0	P2
P1=1 if PT=1 (orig. Pub. Type 1)	F2.0	P1
P9=1 if PT=9 (orig. Pub. Type 5,6,7,8,9,0)	F2.0	P9

BIGPF2 is a reduced version of BIGPF by deleting some unnecessary variables. BIGPF3 is corrected version of BIGPF2. The correction on PTORG↔P9 to make correct and consistent with BIGQF.

* indicates created variables and the given format is sufficient.

mputed Variables

Summation of cites--1970-78 only for non-self cites	V301
" " " self cites	V302
" " " not known if self cite or not	V303
" " " all cites = V301 + V302 + V303	V304
" " " excluding known self cites = V301 + V303 - V302 (not very useful)	V305
Log of P2 publications = ln(P2 + 1)	LGP2
log of citations = ln(V304 + 1)	LGTN
Learning composite measure on dissertation =(V96 + V97 + V98 + V99)/4	V307
Satisfaction with diss topic,area,field,phd attained = (V101 + V102 + V103 + V104)/4	V308
Inclination to pursue diss research = V93 or V94 (greater of the two)	V309
Inclination to pursue diss research + res value of diss = (V309 + V95)/2	V310
Inspiration, larger of supervisor and committee (V83, V84)	V311
Age at PhD = YR - V2	AGE
Time from BS to PhD = YR - V9 (or V14)	TIME
Masters degree obtained= if V10 or V5 or V15 eq 2 (masters)	MS
Institution number code = 10000 * State + SCHID	SCH
Change of school = SCH - V6	SHIFT
Change of school = SCH - V11	SHIFT2
Academic career pattern dominant = V203 GE .5	AC
Productive researcher = P2 GE 3	RES
Roose-Andersen rating made discrete = ROOS GE 4 = 4; ROOS GE 3, LT 4 = 3; ROOS GE 2, LT 3 = 2; ROOS LT 2, GT 0 = 1	ROO
Primary work activity on current job: Research related = 1,2,4 = 1; Teaching = 3 = 2; Professional service,etc. = 5,6,7 (admin,other) = 3	CAREER
Field shift = V60 - V125	V312
General grad education affect response = (V102 + V103 + V104)/3	V313
Res value of diss indicator = (V95 + V101 + V309)/3	V314
Log of diss-derived publications = ln(PUCF + PUCG + 1)(corrected for miss.vals)	V316
Absolute value of field shift(to gauge how far a person has shifted)	V312A
Conflict = greater of V80,V81,V82	CONFLICT
Articles, bks, chaps, prc's for 1973 on (measure of research orientation)	V317
" " " " - truncated: 1= GE 3, 0= LT 3 on V317	V318
Academic vs. non-academic: a cleaner cut with 1= LE .1 FTE is acad; 2= GE .9 FTE is acad; in between declared missing value	V319
PhD aims - maximum of teaching, prof service, and other in seeking PhD	X
Difference of research aim in seeking PhD and X	AIM
Current percent time on research truncated: 1= LE 10%, 2= GE 33%, in between declared missing value (intended for use as an indicator of res orient.)	V320
Extreme scores--1= high res aim in seeking PhD and V318 is 0; 2= lo res aim in seeking PhD (1 or 2 on 5 pt scale) and V318=1	V321
" " 1= hi res aim, and V120 LE 10--% time on res in first job; 2= lo res aim, and V120 is other, but neither V45 nor V120 blank	V322

(File QA takes file BIGQF up thru all changes in intermediate files QNEW--QNEW3. See runs Q-27 for basic modifications; run P-8 for data aggregation from P file, citation data; and Q-28 for adding that in to Q file.)
(Data added here from P file-- VV33 - VV38, V304X, V304YX all have missing values (-99) for the 52 cases for which category was not determined for a majority of the publications in CTGY 2.)

Primary work activity: as in CAREER, except that Research related = 1,2	CAREER2
All publications for the new data (not old psych) searched for cites thru 1978 only, excluding the 52 cases	V304X
V304X/(78 - Year of pub)	V304YX
--for CTGY 1-- cites(V304X)	VV31
" yearly cites (V304YX)	VV32
--for CTGY 2--cites	VV33
" yearly cites	VV34
--for CTGY 3—cites	VV35
" yearly cites	VV36
--for CTGY 4--cites	VV37
" yearly cites	VV38

Index to Variables in BIGPF3

PUBLICATION FILE

Description	Format	Variable Name
Variables on Publications from New Survey Respondents		
Publication field	F1.0	PF
Person identification number	F3.0	PID
Publication number	F4.0	PN
Publication respondent - 4 letters	A4	PR
Publication First Author Last Name	A9	PFA
Publication First Author Initials	E2	PFAI
Multiple Authorship 1 = Single 2 = Multiple	F1.0	PM
Journal Name	A10	PJ
Volume	A5	PV
Page	A5	PP
Publication Year 1=≤62, 2=63-66, 3=67,68, 4=69-72 5=73-74, 6=≥75	F2.0	PYR
Type of publication (see below)	F1.0	PT=1 if TYPE=1 2 if TYPE=1, 9 if TYPE=Ot
Same as VV1-VV30 in BIGQF (see "PhD Q Codebook")	F2.0 F5.0	V1-V30 TOTN
Variables from Old Psychologist File		
Order of Authorship 1 = First author (is our respondent) 0 = Not first author	F1.0	GCODE
Publication year	F2.0	GYR
Months of effort invested in the article	F5.1	GMO
See "Index to Variables in BIGOQ"	F2.0	GSC64 -GTC72
Combined Variables		
Category 1 = Pre-Dissertation 2 = Directly from Diss. 3 = Continuation of Diss. work 4 = Post PhD, non-Diss. related	F4.2	CTGY*
Effort recorded (from PS & GMO) to 1. <2 mos. FTE 2. 2-6 Mos. FTE 3. > 6 Mos. FTE	F5.2	SCALE*
Type of Publication (1) Article (2) Book (3) Bk Chapter (4) Proceedings (5) Presentations at meetings (6) Diss. (7) Tech Reports (8) Abstracts (9) Masters Thesis (0) Misc. (Newsletters)	F3.1	PTYPE*
Year of Publication (e.g. -69,70,71 vs. PYR 'coded')	F4.0	PYEAR*
Original Pub Type coded as 1,2,...,0	F2.0	PTORG
P2=1 if PT=1,2 (orig. Pub. Type 1,2,3,4)	F2.0	P2
P1=1 if PT=1 (orig. Pub. Type 1)	F2.0	P1
P9=1 if PT=9 (orig. Pub. Type 5,6,7,8,9,0)	F2.0	P9

BIGPF2 is a reduced version of BIGPF by deleting some unnecessary variables. BIGPF3 is corrected version of BIGPF2. The correction on PTORG→P9 to make correct and consistent with BIGQF.

* indicates created variables and the given format is sufficient.

Index to Variables in BIGQQ (Old Psychologists)

Description	Format	Variable Name
See the old master codebook		VAR001 ~VAR231
See "PhD Q Codebook" for BIGQF In particular, the extended portion		TOTN ~PUYR
See "PhD Q Codebook" Same as VV1~vv30 in BIGQF	F3.0	VI~V30
Self-citations (by respondent or collaborator--usually known in 1964	F3.0	GSC64
Total citations in 1964		GTC64
		GSC65
etc.		GTC65
		GSC66
		GTC66
		GSC67
		GTC67
		GSC68
		GTC68
		GSC69
		GTC69
		GSC70
		GTC70
		GSC71
		GTC71
		GSC72
		GTC72
Totan N of Publications not first authored		G1
Total N of Publications First Authored	F3.0	G2

Index to Variables in CITSRT5 (Citation File)

Description	Format	Variable Name
Citation journal	A10	CJ
Citation volume	A5	CV
Citation page	A5	CP
k-code from ISI (SCI)	A2	CK
Citation year (single digit for 197 ~)	F1.0	CY*
Citing author	A10	CA
Publication (cited) page	A5	PP
Publication field ID	F1.0	PF
Publication-respondent ID #	F3.0	PID
Respondent's name	A5.0	PR
Publication first author	A10	PFA
Initials of the first author	A3	PFAI
Multiple author, blank = unknown 1 = single 2 = multiple	F2.0	PM
Publication journal names	A10	PJ
Publication journal volume	A5	PV
Publication year	F3.0	PY
Publication category**	F2.0	PC
Publication scale**	F2.0	PS
Publication type**	F2.0	PT
Publication ID number	F5.0	PN
Self-citation, blank = non self cite 0 (zero) = unknown 1 = self cite	F2.0	SC
Citation year (70 + CY)	F3.0	CYR
Sequence number in a previous file	F6.0	OLDSEQ*
Sequence number in a previous file	F6.0	NEWSEQ*

*CY, OLDSEQ and NEWSEQ are not saved in CITSRT5 data file.

**Explained elsewhere as category, scale, and type.

Note: Citation information obtained from SCCI by us (3231 cases) does not include publication information. The order of the variables in the data file is different from CITSRT5.

Appendix C

CONSTRUCTION OF DISSERTATION VALUE INDICATORS

The questionnaire posed a number of questions relevant to evaluation of the worth of the dissertation experience. The most direct was

How would you evaluate your dissertation experience in terms of:

⋮

generally being a valuable experience (V100)

The other variables considered to be of possible relevance to this issue (paraphrased and shortened) are indicated in Figure A-1.

We first examined the correlation matrix among the raw variables - 16 in all, before composites constructed. This was done for all fields together, for sociology, and for biochemistry. The impression from this pairwise deletion set of correlations was that there was something here. V100 was particularly interlinked with most of the others, most of the time. Field differences did not preclude seeking a common metric. See the matrix attached.

We then constructed composites and sketched out a conceptual path model to postulate latent factors that might account for the observed correlation patterns. The conceptual model seemed generally nicely in line with the raw correlations so we proceeded.

Multiple regressions were performed (Run Q-4) as well as a series of factor analyses. Results seemed to converge well with the general profile of the path model. Results were balanced against the general Connolly principle that how you weight particular components in a linear model is of little consequence. Based on the analyses, we propose to use

V100 as a general indicator of affect value of the dissertation

(V95 + V101 + V309)/3 as an index of the research value (intellectual) of dissertation (dividing by 3 only to keep the means roughly comparable; in general, the standard deviations of these 1-5 scaled variables are close to 1.; means are usually somewhere around 3.5-4.0)

(V96 + V97 + V98 + V99)/4 as an index of the training value of the dissertation

(V102 + V103 + V104)/3 as a general index of affect toward the graduate education experience, rather than toward the dissertation. (We suspect this will not be used as much.)

We find it interesting that the variables that seemed to come together are quite reasonable "effect indicators." Only the research value measure is at all complex, and accordingly it may be the most robust of the lot.

None of the "Causal" indicators (such as V91 - adequate facilities) emerge
Those would have been conceptually more awkward to accommodate - see the latent variable path model.

We intend to use the resultant indicators in various analyses of what makes the dissertation experience good or bad. Sometimes, we may aggregat the first three indexes to yield a grand composite for the worth of the dissertation. This will be computed as

$$[(V103 + (V95 + V101 + V309)/3 + (V96 + V97 + V98 + V99)/4)/3]$$

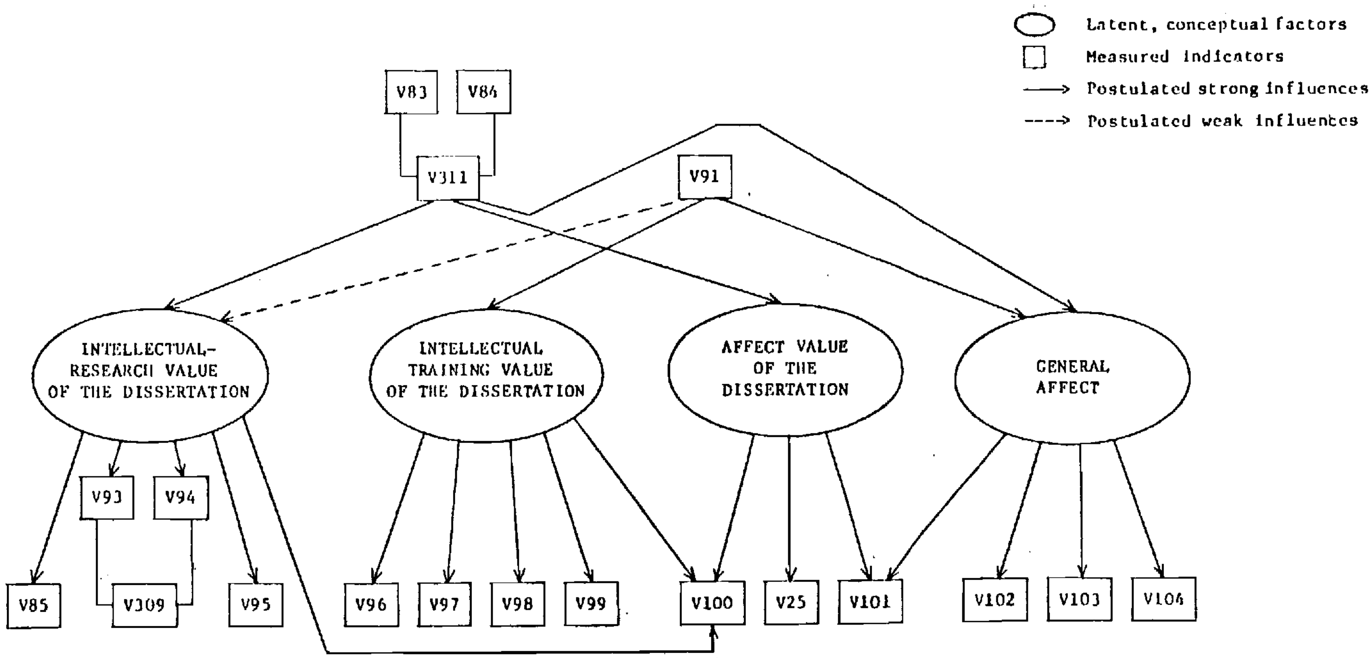
Pearson Correlations (r) Among Indicator Variables

Values shown are: all fields combined / Sociology alone / Biochemistry alone

	75	83	84	85	91	93	94	95	96	97	98	99	100	101	102	104
75																
83	04 / 15 / -05															
84	04 / -11 / 07	14 / 31 / 12														
85	10 / -01 / -10	17 / -02 / -11	05 / -11 / 15													
91	-12 / 01 / -01	17 / 19 / 35	05 / 22 / 10	-15 / -16 / -02												
93	06 / -31 / -07	19 / 27 / 20	16 / 07 / 06	02 / -02 / -00	12 / 18 / -05											
94	04 / -06 / 11	05 / -07 / -10	00 / 01 / 07	02 / -03 / 17	-02 / -10 / -07	-17 / -46 / -19										
95	16 / 03 / -13	22 / 11 / 38	16 / 09 / 17	-09 / 07 / -17	13 / 02 / 43	32 / 23 / 15	13 / -07 / 03									
96	10 / 05 / 15	17 / -02 / 31	10 / -07 / 11	-06 / 07 / -04	24 / 42 / 17	17 / 10 / 11	06 / 23 / -22	26 / 13 / 15								
97	-12 / 01 / 07	17 / 12 / 15	08 / -07 / 03	-12 / 09 / -03	20 / 30 / 12	29 / 17 / 16	-02 / 15 / 07	24 / 12 / 31	44 / 56 / 42							
98	-06 / 11 / 05	19 / 10 / 15	14 / 08 / 03	-06 / -05 / -22	23 / 43 / 22	14 / 24 / -04	10 / 10 / 13	21 / 08 / 25	38 / 47 / 37	34 / 48 / 24						
99	07 / -05 / 07	06 / -02 / 04	18 / 13 / 16	-08 / -05 / -01	11 / 26 / 11	12 / 16 / -10	02 / 18 / -16	11 / -00 / 07	24 / 37 / 25	30 / 45 / 43	41 / 48 / 31					
100	13 / 17 / -13	11 / 17 / 11	14 / 08 / 15	-11 / 07 / -10	20 / 30 / 14	24 / 27 / 18	07 / 15 / -18	36 / 31 / 36	47 / 37 / 57	44 / 48 / 44	37 / 46 / 26	43 / 45 / 34				
101	02 / 15 / 11	11 / 10 / 16	11 / -01 / 03	-01 / 17 / -17	20 / 17 / 17	24 / 33 / 21	11 / -11 / -02	53 / 48 / 57	21 / 23 / 31	23 / 29 / 15	20 / 20 / 17	19 / 05 / 15	40 / 46 / 37			
102	01 / 10 / -03	11 / 18 / 16	14 / 11 / 17	22 / 07 / 05	17 / 33 / 24	14 / 23 / 12	-06 / 28 / -14	20 / 26 / 23	18 / 27 / 17	19 / 23 / 18	15 / 32 / -03	06 / 07 / 07	27 / 35 / 28	46 / 44 / 49		
104	08 / -07 / -14	11 / 14 / 05	10 / -07 / 19	03 / 15 / -12	05 / 15 / 05	11 / 12 / -05	-06 / -07 / -06	06 / 05 / 04	14 / 21 / 13	16 / 16 / 14	07 / 16 / -02	15 / 07 / 22	23 / 30 / 24	20 / 21 / 19	33 / 43 / 31	

Figure A-1. Conceptual Path Model for Dissertation Value Indicators

(V25) Was the dissertation too long in FTE months
(V85) Co-author with supervisor
(V91) Research facilities adequate
Evaluate dissertation in terms of
(V95) valuable research
(V96) learn to do independent research
(V97) learn specific research skills
(V98) learn to write for publication
(V99) learn other professional skills
(V100) Generally being a valuable experience
(V101) Satisfied with choice of dissertation topic
(V102) Satisfied with specialty area
(V103) Satisfied with field
(V104) Satisfied with getting PhD
(V309) Did carry on or would have liked to carry on the dissertation research
(V311) Inspired or stimulated by supervisor/other committee members



The Doctoral Dissertation— How Relevant?

Doctoral training of engineers has been criticized as a poor grounding for professional practice. The authors' study of EE doctorates reveals surprising support for current dissertation practices and for the doctoral experience in general.

Terry Connolly
Alan L. Porter
Georgia Institute of Technology

How well do current practices in doctoral engineering education serve the needs of those who pursue these degrees? Specifically, are these practices excessively biased toward training students for scholarly research, and away from useful practical applications? The existence of such a bias is strongly argued by several commentators, particularly those who advocate "professional" degrees, and even "professional" schools, for engineers. Thus Dillard, a former president of the IEEE, argues forcefully that "The present design of advanced engineering education does not meet the needs of the engineering manpower marketplace."[1] He suggests that engineering faculty have little experience of engineering practice, are rewarded for sponsored, publishable research, and thus steer their students into similar studies at the expense of training them for high-level professional practice. Similarly, Kerr[2] suggests that academic research neglects useful application in favor of more "basic" areas, and that an individual faculty member's interest in a topic, availability of funding, suitability for individual or small-group work, and short time-frame for results are the deciding factors. Similar critiques are offered by Brooks,[3] Pierce,[4] Fadum,[5] Weinberg[6] and others, focusing both on doctoral education in general, and on the doctoral dissertation in particular.

While such arguments are often forcefully made, and by distinguished members of the profession, the empirical base on which they rest is not entirely satisfactory. On one hand, extensive data are available on the demographic characteristics of holders of doctoral degrees in engineering: their age, sex and race; geographical distribution; employment patterns and earnings, and so on.[7-9] On the other hand, little information is available on what might be called the "process issues of engineering doctoral education: how individuals choose a Ph.D. program; the course work and research they complete; how dissertation topics are chosen, and when; how individuals evaluate their experiences; and how these experiences affect their later professional careers.

We recently completed a study addressing several of these "process" issues for a sample of doctorate holders in six disciplines, including one branch of engineering.[10] This article reports the results for the sample of electrical engineers included in the larger study.

In February 1979, we mailed a six-page questionnaire to a total of 150 individuals selected randomly from those listed in *Dissertation Abstracts* as having received Ph.D's in electrical engineering at American universities during 1969-70. After extensive follow-up letters and phone calls, we received a total of 106 essentially complete responses (71 percent). The analyses reported here are based on these 106 replies.

Personal Characteristics and Work History

Of our 106 respondents, all but one was male, reflecting the sexual makeup of engineering graduate schools until quite recently.[1] Their average age (in 1980) was 41, with quite a tight clustering around that age—almost 80 percent of the sample were born between 1936 and 1943, though our youngest respondent was born in 1945 and our oldest in 1917. Most (76 percent) are currently married, 22 percent have never married, and 2 percent reported themselves as divorced, widowed or separated. These characteristics appear representative of other samples of engineering Ph.D. holders.[7-9]

We asked our respondents to indicate how long they had been employed since earning their doctorates, by each of four classes of em-

Volume 71, pp. 162-166.

ployers. The responses are summarized in table 1. Fully three quarters of our respondents have worked in business or industry at some time since completing their doctorates, and nearly one third have worked only for such employers. A little over 40 percent have held academic jobs, though few (less than 7 percent) have held only academic jobs. About 15 percent have worked for government organizations at some time, though few (under 4 percent) only for such organizations; other forms of employment are rare, and no one reported only such employment since graduating. There is little evidence here of any substantial periods of unemployment: our typical respondent reported a total of 9.7 years of full-time employment, of the 10 years or so that have elapsed since graduation. (Again, our sample profile parallels closely that of engineering doctorates as a whole.[7-9]

Primary work activity has shifted markedly over the decade since graduation, as shown in comparing first post-Ph.D. jobs with current jobs (table 2). In rough terms, about half of our respondents entered jobs involving teaching, research or a combination of the two as their first post-Ph.D. job, about 40 percent went into design or development, with only 10 percent in other types of work (administration, professional service, etc.) Current jobs, in contrast, show a marked decline in the first two categories, and marked growth in the third. Fewer than a third of the respondents are now in research or teaching, or both, a few less (28 percent) are in design and development, and over 40 percent are now in other types of professional work, primarily administration and management (25 percent). The shift is clearly seen in the average percentage of time devoted to research: for initial jobs, the mean percentage reported was 43.1 percent, but only 24.6 percent for current jobs.

The shift in work patterns is reflected in levels of supervisory responsibility (table 3). Again, the shift in these responsibilities with career growth is clear. A large majority (83 percent) reported essentially no significant supervisory responsibilities in their first post-Ph.D. jobs, a figure which has fallen to below 40 percent for current jobs. Twelve percent started with supervisory responsibilities at the project or section level, while over 40 percent now hold such jobs. Only 3 percent initially held management responsibilities at the level of a major department or above; 18 percent now do. Quite clearly, the pattern of a shift over time from primarily technical to primarily managerial jobs is reflected in both tables 2 and 3. The financial rewards are commensurate. We found that well over half our respondents earn more than $36,000 annually from their professional work. While 37.4 percent reported earnings over $40,000, only 3.9 percent earn less than $24,000.

Table 1. Employment Since Earning Doctorate.

Employer Type	*Full-Time Years of Employment* 0	*1-2*	*3-5*	*6-9*	*10*	*Mean*
Business or industry:	25.7%	6.7%	11.5%	24.8%	31.4%	5.7 years
Academic institutions:	58.1	6.7	12.5	16.2	6.7	2.6 years
Government	84.8	3.9	3.8	3.9	3.8	0.9 years
Other (e.g. self-employed)	91.4	1.9	3.8	2.9	0.0	0.4 years

Table 2. Primary Work Activity, First Job vs. Current Job.

Primary Work Activity	*First Year Post-Ph.D. Job*	*Current Job*
Research	30 (28.3%)	16 (15.1%)
Research & Teaching	8 (7.5)	12 (11.3)
Teaching	14 (13.2)	5 (4.7)
Development, Design	42 (39.6)	30 (28.3)
Professional Service (or technical staff not R&D)	7 (6.6)	9 (8.5)
Administration, Management	2 (1.9)	27 (25.5)
Other	1 (0.9)	7 (6.6)
(No response)	2 (1.9)	0 (0.0)
Total	106 (100%)	106 (100%)

Table 3. Supervisory Responsibility, First Job vs. Current Job.

Supervisory Responsibilities	*First Year Post-Ph.D. Job*	*Current Job*
No personnel supervision	64 (60.4%)	13 (12.3%)
Indirect or staff supervision (no line authority)	13 (12.3)	17 (16.0)
Supervise students	11 (10.4)	12 (11.3)
Supervise team, unit, project or section	13 (12.3)	45 (42.5)
Manage major department or division	1 (0.9)	15 (14.2)
General management of organization	2 (1.9)	4 (3.8)
(No response)	2 (1.9)	0 (0.0)
Total	106 (100%)	106 (100%)

Dissertation Experiences

The typical respondent reported spending the full-time equivalent of a little over three years (37.2 months) in the doctoral program, of which 14.9 months (39.9 percent) were devoted to dissertation work (counted from approval of proposal to completion of dissertation). Most (67 percent) felt that this allocation was about right, 22 percent felt it was too long, and only 10 percent felt it was too short. Regarding the distribution of time across the various aspects of dissertation-related work, respondents reported spending 37 percent of their time on problem formulation, conceptual or theoretical development. Writing took almost 20 percent of most respondents' dissertation time, data gathering and analysis around 15 percent each, and equipment preparation a little less than 10 percent. Respondents typically found this distribution reasonable, with quite small variations between reports of time actually spent on each phase and what the respondents would regard as "ideal."

We also asked the respondents when in their doctoral studies they began work on their dissertation. The replies showed considerable variation, with significant numbers starting dissertation work in the early stages of course work, others not starting till after completion of their comprehensive examinations. Most of those making a relatively late start felt that they would have liked to start earlier, with most respondents indicating that a start on the dissertation by early or middle course work would be desirable.

Choice of Dissertation Topic

We asked our respondents to characterize their dissertations along four dimensions: Theoretical vs. Empirical/Experimental; Laboratory vs. Field; Individual vs. Collaborative; and Basic vs. Applied. Their responses showed rather wide scattering along two of the dimensions, much less along the others. On the Theoretical vs. Experimental dimension, a sizeable number of dissertations were rated in each category, with a slight numerical bias towards the "theoretical" end. On the Basic vs. Applied dimension, there was also a considerable range, with a distinct bias towards the more applied end of the scale. Of those reporting any significant data-gathering effort, most worked mainly or entirely in the laboratory rather than in the field. Finally, very few of our respondents reported any significant collaboration in their dissertation work: the strong bias is towards "individual" rather than "collaborative" studies.

Table 4. Importance of Factors Affecting Choice of Dissertation Topic.

Factor	*Mean Importance Rating* (1=Not imp. 5=Very imp.)
Scientifically important topic to which you could make a real contribution	3.3
Special inherent interest, personally meaningful	3.6
Manageable study, reasonable time-frame	3.6
Faculty (supervisor) preference	3.2
Other factors (e.g. funding or lab facilities available)	2.8

Respondents rated five factors in terms of their importance in the choice of a dissertation topic (table 4). While all five factors were typically rated as of significant importance, those generally rated highest were personal interest in the topic, and a need for a study of manageable proportions. Scientific contribution and faculty interest were rated somewhat less important, with environmental pressures such as funding and lab facilities least important overall. These ratings suggest a fairly open personal choice of topic.

The respondents' assessments of the criteria by which their dissertations were evaluated are suggested in table 5. Again, each of the criteria was seen as generally important, two particularly so: the researcher's demonstration of research competence, and originality. The work was expected to be practically relevant and to make a scientific contribution. Least importance overall was attached to obtaining positive findings. Again, the two criteria rated most important overall are those associated with the educational aspect of dissertation work—learning and demonstrating research abilities—with criteria associated with the actual production of scientific findings, while important, rating second to these.

Table 5. Importance of Criteria Used in Evaluating Dissertations.

Criterion	*Mean Importance Rating* (1=Not imp. 5=Very imp.)
Originality (no similar prior work)	3.9
Significant scientific contribution in findings	3.5
Positive findings (confirmation of hypotheses)	3.3
Practical relevance of findings	3.6
Demonstration of research competence	4.2

Assessments of the Dissertation Experience

As noted earlier, a major focus of the study was on the respondents' assessments of their own dissertation experiences, of dissertation practices generally found in their field, and of a number of possible changes in these practices. The respondents' assessments are summarized in table 6. As the table suggests, our respondents were generally quite satisfied with most aspects of their dissertation experiences. They rated the dissertation as a generally valuable experience, particularly in teaching them the skills of independent research. They were a little less satisfied with what the dissertation taught them about professional writing, with other non-research professional skills, and with the scientific yield of the work itself. Even these aspects were, however, typically rated as at least moderately satisfactory, and the overall experience was rated as strongly positive, particularly in the area of learning how to do research on one's own.

With these generally positive evaluations in mind, it is not sur-

Table 6. Evaluations of Dissertation Experiences.

Aspect considered	*Mean Rating* (1=Not satis. 5=Very satis.)
Yielding valuable research findings	3.1
Learning to do independent research	4.3
Learning work-relevant research skills	3.9
Learning effective professional writing	3.6
Learning valuable non-research professional skills	3.1
Generally being a valuable experience	4.1
How satisfied are you with your choice of dissertation topic?	3.6

Table 7. Evaluations of Possible Changes in Doctoral Program Practices.

Proposed Change	*Mean Rating* (1=Strongly disapprove 5=Strongly approve)
Overall increase in standards and requirements to obtain Ph.D. (e.g. increased course work, publication)	3.1
Several small original research exercises in lieu of the dissertation	2.0
Dissertation research as at present, but several short reports, more like articles, in lieu of the written dissertation as presently required	2.3
Extended practicum or internship activities to acquire professional skills that are not research-oriented, in lieu of the dissertation (within a Ph.D. program)	2.3
The option of alternative doctoral degrees (e.g. doctor of engineering) not oriented toward research	2.8

prising that our respondents are basically satisfied with dissertation practices in their area.

We found that over half our respondents felt that current levels of emphasis on *originality* were about right, with the bulk of the remainder feeling that this is emphasized too little. Similarly, the majority felt that appropriate emphasis was given to *obtaining positive results*, though a substantial number (25 percent) felt that this was somewhat overemphasized, and few felt it was underemphasized. Rather less satisfaction was expressed about the degree of emphasis generally given to *matching the dissertation to the student's career needs:* more than half our respondents felt that this aspect was underemphasized in the field, and few felt it was overemphasized. Average ratings for the sample as a whole, however, fell quite close to the "emphasis about right" range in all three areas.

The final item in our survey asked the respondents to evaluate a number of possible changes in doctoral programs, primarily focusing on alternatives to the traditional research-oriented dissertation. These evaluations are summarized in table 7.

These proposals generated a wide range of reaction, with responses ranging from strong approval to strong disapproval on each question. Overall, however, there was little enthusiasm for any of the changes among our respondents as a group. The only proposal scoring above neutral overall was the first one, for general tightening of standards. Close to neutral, but slightly disapproved of on average, was the proposal of alternative, non-research doctoral degrees, such as the doctor of engineering. Modifying the requirement of a written dissertation to require several shorter, article-length reports was, on the average, rated somewhat negatively, as was the proposal to replace the dissertation with non-research practica or internship activities. Least approval overall was expressed for the idea of doing several smaller research exercises instead of a dissertation.

Implications for Doctoral Research

How do these findings fit with the concerns about engineering education summarized in our introduction? In general, they appear to present a much rosier picture than we had anticipated at the outset of the study: doctoral education in engineering appears to be in reasonably good health, at least in the view of those completing the Ph.D. in electrical engineering in 1969-70, and now looking back from a ten-year perspective. Several points supporting this broad conclusion deserve to be emphasized:

- Our sample appears to be representative of engineering doctorate-holders as a whole. Our sampling procedure strictly allows inference only to a particular discipline (electrical engineering), and only to a particular group (those receiving the Ph.D. in 1969-70). Comparison of this sample with published data on engineering doctorates as a whole, however, suggests no major anomalies: their demographic characteristics, work experiences, job responsibilities and earnings are consistent with available data on engineering Ph.D.'s generally. Further, the perspectives they offer are not limited to a particular branch of the profession. Academics, researchers and managers employed by industry, government and academe are all represented. To the extent possible in a single study, we can claim that the views expressed are reasonably representative.
- As critics have implied, doctoral research is likely to be a sol (rather than a group) effort, and i data-based, to be conducted in th laboratory rather than the field. O the other hand, more of the studie were seen as applied than basic, an most involved at least some actua data-collection. This finding i markedly at variance with the ivor tower, basic science, pure theor image often presented by critics.

• A similar disparity is seen in the factors influencing choice of topics. As table 4 suggests, personal interest and scientific merit are seen as important factors influencing choice, as well as pragmatic considerations of biting off a study of manageable scope and duration. Again, the critics' image of assertive faculty dominating students to choose topics of faculty interest, or pushing them into externally-funded projects, is not supported here; such influences were rated least influential overall. Most students chose their topics largely for their own reasons, and were generally satisfied with their choices (table 6).

• Dissertations are evaluated primarily on their demonstration of research competence and originality (table 5). Practical relevance of findings is still seen as of significant importance, ranked ahead of scientific yield or hypothesis confirmation.

• In general, our respondents were strongly positive about their dissertation experiences, basically as a means of learning to conduct independent research (table 6). They felt that the emphasis given to different aspects of the experience was about right, or reasonably close to being right. And they showed little enthusiasm for any of the various changes proposed for doctoral programs (table 7). In short, while there is clearly room for improvement in specific areas, our respondents see those changes more as incremental improvements in the current system rather than radical rearrangement of the way doctoral study in general, and dissertation research in particular, is conducted.

Conclusion

The findings reported here suggest that advanced engineering education may be in less of a crisis than has been suggested by some of its more trenchant critics. From our initial reading of a sample of such critics, we expected to discover widespread discontent and a strong desire for reform among our sample of ten-year-out doctorate holders. We were surprised. Where the critics have painted a picture of ivory-tower academics steering students into theoretical, basic-science projects, driven by external funding and pressures for publication, we found a rather different reality: strong interest in practical relevance, projects primarily chosen by the students, little reported influence of funding opportunities. Where the critics have suggested that such training leaves the graduate ill-equipped for useful employment outside of academe, we found a majority of our respondents so employed: most work for business or industrial employers, earn good salaries, have not been unemployed and are moving into supervisory and senior managerial jobs.

We should, of course, not paint an over-rosy picture. Within the scope of this study, there are clear areas for concern for engineering educators involved in the training of Ph.D.'s. Further, our data do not bear on such issues as the teaching effectiveness of engineering faculty who have had limited, or no, practical experience outside the university (though very few of our respondents appear to fall in this category). We find, nonetheless, a sharp contrast between our findings and the cataclysmic image presented by Dillard of the engineering professoriate "... unbending, resistant to change, stifled in its committees, boards and faculty senates" and leading to "... the slowing of the wheels of industrial and economic progress and a gradual destruction of society as we know it."[12]

To the extent that our respondents constitute a part of the process Dillard outlines, they largely refute it. Looking back with ten years of their careers behind them, they report their doctoral experiences in generally positive terms, see modest needs for improving the educational programs—and appear to be gainfully, and remuneratively, employed. Current Ph.D. practices in engineering are, certainly, not beyond improvement; but nor are they without merit or beyond hope.

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APPENDIX E

Physicists and the Doctoral Dissertation*

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ABSTRACT

This article is based on a recent study of 645 1969-1970 PhD recipients from the disciplines of physics, electrical engineering, biochemistry, zoology, psychology, and sociology. It focuses on the 97 physicists in the sample, studying their personal characteristics, work histories, dissertation experiences and assessment of their worth, and early career productivity including publications and citations. In the process of analyzing the physicists' careers, it compares them as a group with the other disciplinary groups and the sample as a whole. There is general satisfaction with the dissertation experience and little inclination to change its structure. However, the data suggest certain areas where improvement is possible in the dissertation process. These include beginning the dissertation during course work, increasing the relevance and originality of the dissertation, and using the dissertation experience as an opportunity to begin learning research management.

INTRODUCTION

The capstone of the formal education of U.S. physicists is the PhD degree. This degree plays the role of a credential that certifies that its holder is capable of undertaking independent research. This research capability is evidenced primarily by successful completion of the PhD dissertation. Physicists as a group have not been overly critical of the doctoral dissertation, but concern with the form and scope of the dissertation requirement has been expressed in other fields[1,2].

Several serious concerns prompted the present study. Historically, the dissertation has evolved into a research requirement[3] resting on two pillars: that the dissertation produce original and significant <u>scientific contributions</u>, and that it provide <u>training</u> for a research career. These pillars are not necessarily mutually consistent. One could surmise that scientifically fruitful dissertations might not provide felicitous training, or vice versa. Moreover, one can question the research orientation reflected in an Association of American Universities policy statement of 1904 (still held by the Council of Graduate Schools), "The Doctor of Philosophy shall be open as a research degree in all fields of learning, pure and applied." Teaching and professional practice are prominent alternative rationales to seek the PhD.

Even if one accepts the research-oriented PhD and the dissertation requirement as givens, there is the further question of how they may be structured most effectively. This study aimed to provide first-hand evidence of dissertation practice with respect to characteristics that might affect doctoral training outcomes. For instance, one area studied is the balance of evaluative criteria imposed on PhD candidates - originality, significance, positive (confirmatory) results, relevance. There are striking cases that suggest these may not be optimally balanced. As Gabor notes[4]:

> I have been asked more than once why I did not invent the laser. In fact, I have thought of it. In 1950, thinking of the desirability of a strong source of coherent light, I remembered that in 1921, as a young student in Berlin, I had heard from Einstein's own lips his wonderful derivation of Planck's law which postulated the existence of stimulated emission. I then had the idea of the pulsed laser: Take a suitable crystal, make a resonator of it by means of a highly reflecting coating, fill up the upper level by illuminating it through a small hole, and discharge it explosively by a ray of its own light. I offered the idea as a Ph.D. problem to my best student, but he declined it as too risky, and I could not gainsay it, as I could not be sure that we would find a suitable crystal.

This study set out to examine such factors concerning graduate training practices and how they bear on several outcome measures.[5] First, we wanted to examine what satisfaction a cohort of recent PhDs felt toward their dissertation experiences, and what factors most related to this satisfaction. Second, we were interested in whether these graduate training factors predicted early career productivity. Third, we wished to discover opinions regarding several potential changes in doctoral training policies.

THE STUDY

This study focuses on 1969-70 doctoral recipients from six diverse disciplines. It addresses their dissertation, related doctoral training experiences, and their early profesisonal careers in light of this experience. In addition to physics, the disciplines are biochemistry, zoology, electrical engineering, psychology, and sociology. These fields span the National Research Council (NRC) categories of science-based disciplines. A sample of about 400 per field was taken by random draw from 1970 Dissertation Abstracts. The NRC matched this list with their data to eliminate duplicate last names and initials. From those remaining, we randomly selected about 200 per field, to survey in Spring, 1979. Subtracting those to whom we were unable to deliver the questionnaire, we obtained a response rate of 70.0% (645). Our sample of physicists numbered 97, a 64.2% effective response rate. The respondents also offered comments and corrected and expanded our compilation of their career publications (from Science Citation Index - SCI), indicating the relationship of each publication to their dissertations. We later tracked citations to those publications through an Institute of Scientific Information computer search. While non-respondents published slightly less than respondents (mean publications of all respondents 6.46; of non-respondents, 5.96; and of those for whom addresses were not found, 4.81), on essentially all demographic attributes, our sample matched NRC tabulated population attributes closely.

PERSONAL CHARACTERISTICS AND WORK HISTORY OF RESPONDENTS

Among our 97 physicists there were only two women. Physicists were the most homogeneous graduate student population with 93% of those surveyd having a bachelor's degree in physics (the other extreme being sociology at 29%). Median age at the doctorate was 29, for physicists and for the six fields together, with 77% of the physicists being born between 1938 and 1943. The median total time between the bachelor's degree and the doctorate in physics was 6.8 years with the mean being 7.5. That was about the same as zoologists and electrical engineers, about a year longer than biochemists and psychologists, but over two years shorter than sociologists. During the year prior to the PhD, 85% were married while 14% had never married. Both the mean and median number of dependents at this time were two, not counting oneself.

Research interests led physicists' reasons for seeking the PhD (70% rated important), followed by teaching which 54% rated as important (where "important" reflects the respondents rating the particular item 4 or 5 on a

1 to 5 scale from not important to very important). Professional practice, very important in electrical engineering and psychology, was a poor third with 18% rating it important. In this emphasis on research, physicists trailed biochemists (81%) with sociologists lowest of our six field sample at 41%. Teaching was most important to zoologists and sociologists (76%) with electrical engineers (40%) the least academically oriented.

After receiving the PhD, the physicists were employed by a variety of organizations (Table 1). Physicists had a mean full-time equivalent (FTE) academic employment almost twice that in business or industry. Of the six

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TABLE 1 ABOUT HERE
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fields considered, physicists showed the most balanced employment profile across the three sectors. The final column of Table 1 indicates that the standard deviation of physicists from the mean time in academic, business, and government is the lowest of the six groups. Zoologists and sociologists are the least balanced because of their excessive dependence on academia for jobs.

Primary work activity has shifted over the decade since the award of the PhD, as shown in Table 2. Research as the primary activity plummeted

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TABLE 2 ABOUT HERE
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from 49% to 22%. This corresponds with the drop shown in Table 3. The

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TABLE 3 ABOUT HERE
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physicists' decrease in research activity over the decade to 56% of initial activity was the steepest.

Of additional interest is the rise of administration as a primary activity. Table 4 indicates the increase in supervisory responsibility -- note that project, division, and general supervisory responsibility rose from 10 to 47 per-

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TABLE 4 ABOUT HERE
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cent. The increase in administrative responsibility of the electrical engineers closely paralleled that of physicists.[6] The net result of the shifts was a decrease in research activity with a concurrent increase in administrative responsibility - an activity for which the typical PhD does not specifically prepare its graduates.

DISSERTATION EXPERIENCES

With a median of 51 FTE months in the doctoral program, physicists spent the most time of all the disciplines (electrical engineers are lowest with 36 months). Physicists and biochemists spent the longest time on the dissertation itself (counted from the approval of proposal to the completion of the dissertation), median 24 FTE months. The six-field median was 15 months, with psychology lowest at 10 months. There was a bimodal split on when the physicists began their dissertations with "min-coursework" and "after candidacy" being the most common times noted. However, the respondents believed that the dissertation should best begun earlier, in the mid- or later phases of coursework. While only 10% felt that the time spent on the dissertation was too short, 35% felt it was too long, and the majority believed it was just right.

Research assistantships provided the primary means of financial support, both during dissertation research (59%) and writing (55%). Fellowships were second with 19% during the dissertation research and 17% during the dissertation writing. These funds were largely federal in origin as 81% of the physics respondents noted that federal grants were instrumental in the dissertation work, while 41% noted the importance of fellowships or traineeships. The former figure was second only to biochemistry at 89% (six-field mean 62% with sociology low at 27%); while the latter was above only sociology at 33%, with biochemistry again high at 73% (six-field mean 54%). Certainly federal funds for supporting scientific research play a major role in the graduate student's career. Only sociology, which is outside the main interests of the National Science Foundation and the National Institutes of Health, did not have its students heavily supported.

The choice of doctoral program seemed to rest on the balance of several factors. Most important were financial support (64% judged important -- 4 or 5 on a 1 to 5 scale), the reputations of the university (55%) and department (56%), and situational factors (54%). Trailing were reputations of a specialty area within the department (30% important) and of a particular faculty member (27%).

Choice of a dissertation topic also involved balancing a number of factors. Scientific importance was noted as important by 49% of the physicists responding; personal interest, by 56%; manageability, by 47%; environmental considerations, by 44%; and faculty preferences, the most significant, for 65%. Only biochemists at 48% were lower than physicists for personal interest, with zoologists high at 76%. Likewise, only biochemists were higher at 69% for faculty preference than physicists, with psychologists low at 35%. It is not surprising that physicists and biochemists are generally dependent on faculty preferences since they depend overwhelmingly on the availability of support through federally funded projects. Of course, individual differences are pronounced. As one respondent put it: "After a short period of directed reading, I found my own thesis topic"; whereas another reported: "Topics in our research group were essentially assigned by the supervisor."

The character of the physics dissertation was strongly individual rather than collaborative (72% responded 4 or 5 on this 1-5 scale); basic rather than applied (84%); and somewhat bi-modal on a theoretical/ experimental continuum with 20% expressing a theoretical orientation and 68% experimental. These data reinforce the traditional impression of the physics dissertation with the exception that 12% of the respondents note that their work was very highly collaborative. This could reflect the existence of large and well-organized research groups in fields such as high energy physics. A mismatch between such research and completion of dissertations may be building. As one respondent noted: "Experiments in physics generally are becoming much bigger with long lead times - up to 7 years. It is difficult for students to be original in an experiment which involves 25 senior physicists and costs many years." For cross-field comparison, only in electrical engineering did the theoretical and applied orientations dominate.

The rhetoric of the PhD experience emphasizes interaction with and learning from mentors and colleagues. We asked a number of questions regarding supervision and interaction.

Dissertation supervisors tended to be full (61%) or associate (26%) professors. The respondents rated 23% of their dissertation supervisors among the top 5% nationally of scholars in their area of physics while an additional 31% were rated in the next 15%. These ratings appear incongruously inflated until one considers data on the number of other dissertations estimated to have been guided to completion by these supervisors - a median of four and a mean of 10 - indicating that a relatively few professors direct many PhD dissertations. Contrary to the other four fields, physicists and biochemists indicate more productive dissertation experiences when their supervisors had been involved with many othèr PhDs; this could reflect the reinforcement of large and active labs under the leadership of a dynamic professor.

The amount of supervision varied. Moderate supervision by the dissertation director was recorded by 40%; significant supervision in the initial and final phases, by 20%. The dissertation committees played a minimal and generally passive role with 81% supervising minimally and 10% playing a significant role only at the completion of the dissertation. Little or no serious conflict with supervisors or committees was reported in 94% of the cases. Dissertation supervisors were perceived as stimulating to the student (51% were rated as 4 or 5 on the 5-point scale). One physicist commented: "He [mentor] has had a strong influence in shaping me, both in professional and nonprofessional areas - a very positive force in my life." Only 13% of the committees ranked in the same category. As one respondent phrased it: "Once a dissertation is approved by the advisor, it is 'rubber-stamped' by the others on the committee." Sixty-five percent of the respondents coauthored publications with their supervisors. In 31% of the cases the supervisor played an important role in helping to find their first post-PhD job.

Physicists' perceptions of the importance of various <u>criteria applied in evaluating their own dissertations</u> indicate a strong emphasis on demonstrating research competence (mean = 4.2 on a scale from 1 = not important to 5 = very important) with little emphasis on practical relevance (2.0).

In between, they place originality (3.6), scientific significance (3.6), and positive (confirmatory) findings (3.2). We return to these considerations later in terms of the respondents' perceptions of whether changes in emphasis are desirable.

ASSESSMENT OF THE DISSERTATION EXPERIENCE

Respondents were generally quite satisfied with the dissertation experience, although physicists tend to be slightly less satisfied than our six fields combined (Table 5). There was above average satisfaction with the

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TABLE 5 ABOUT HERE
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value of research findings by 49% of the physicists; learning to do independent research, 79%; learning specific research skills relevant later, 78%; learning to write for publications, 51%; learning other professional skills now valuable, 44%; and as a valuable experience overall, 71%. Satisfaction also extends to other aspects of their graduate training. The choice of dissertation topic gave above average satisfaction to 62% of the respondents; the specific area of training to 65%; the field selected to 71%; the fact of earning a PhD to 84%.

Generally, the physicists approved of current dissertation practices (Table 6). To put the results of Table 6 in somewhat different terms, the

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TABLE 6 ABOUT HERE
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emphasis on originality was believed appropriate by 59% while 29% believed it was slightly underemphasized; the emphasis on positive results was believed appropriate by 70% while 24% thought it was emphasized too much. Only relevance was felt to be underemphasized - by 57% of the respondents while 37% thought it was emphasized appropriately.

The respondents were also asked to consider possible changes in the scope and form of the dissertation (Table 6). Increasing standards produced nearly a Gaussian distribution with 33% in the middle of five categories - neutral. Other possible changes were generally disapproved. The general tenor among physics and other PhDs was to let well enough along; there was little support for change.

EARLY CAREER PRODUCTIVITY: DIFFERENCES AMONG GRADUATES OF DIFFERENT INSTITUTIONS

Prominent features of many scientific careers are publication in the open literature (journal articles, books, book chapters, conference proceedings) and citations to those publications. We examined these with respect to the dissertations of our respondents and as to what factors predicted later publications. These are reasonable, though imperfect, measures of research quantity and quality.[7,8]

Table 7 tallies publication and citation counts through 1978 by research category: pre-dissertation, dissertation, continuation of dissertation post-PhD, and other post-PhD work unrelated to the dissertation.

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TABLE 7 ABOUT HERE
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In general, physics results are very similar to the combined six fields, although the latter figures aggregate some sharp field differences. Dissertations do lead to open literature publications - on average, almost 1/dissertation directly plus anoth .75/continuation of the dissertation research. This distribution is skewed though; combining publication from the dissertation and/or from its continuation shows 34.1% of the physicists and 44.0% of the entire sample not publishing at all in either category (or the .79 publications from continuation for all fields combined reflect efforts of 26.3% of the sample).

Citation counts show that the publications tracing their origins to the dissertation are cited more than other work by these same scientists. A better cross-category comparison is to examine citations/year to take account of the differential time periods available for citation to papers published in different years, and to take logarithms to reduce the weighting placed on those few papers that receive large numbers of citations. On log (citations/year), publications derived from the dissertation directly are cited significantly more than later, non-dissertation-related publications by these same authors for physicists and for the six fields combined. A

time profile of when dissertation-derived publications are cited shows a sharp onset for the 1969-70 physics PhDs, peaking in 1972, suggesting that dissertations really are "frontier" science.[5] In sum, dissertations to yield a substantial number of scientifically significant publications, and these are cited slightly more than other work by the same authors.

Interestingly, though not surprising, persons who go on to pursue academic careers (defined here as spending 90% or more of their FTE employment since the PhD in academia, compared to those spending 10% or less) and also those who pursue research careers (defined here as spending 33% or more of their time on research in 1979, compared to those spending 10% or less) produce significantly more publications from dissertations and their continuation. This suggests that what one does with the dissertation bears on one's career.

We have explored a variety of factors concerning the graduate training and related experiences as they may bear on career productivity (e.g., later publications), time devoted to research a decade post-PhD, and other measures, such as salary level and supervisory responsibility.[5] While this is not a clear causal model, we present Figure 1 as a suggestive set of linkages, a cross-field aggregation of some of the associations found.

FIGURE 1 ABOUT HERE

The gist is that where one set forth with an interest in research and/or teaching, benefited from a favorable dissertation experience and a helpful relationship with one's mentor, and pursued post-dissertation research, an enduring commitment to research was nurtured.

In a series of multiple regressions, we examined predictors of career attainments by field and for various aggregations of the combined sample (e.g., academics, researchers).[5] In sum, early publications and percent time on research on the first post-PhD job are the best predictors of later publications and citations, with post-doctoral appointments and the prestige of the PhD-granting department also effective predictors. The only consistent salary predictor was in the negative direction - taking a post-doc.

We now consider the prestige of the PhD-granting department as a dominant predictor of later citations for the physicists and a measure pertinent to certain policy decisions (such as a prospective doctoral student's choice of department and the federal government's support strategies).

Among the most noted overall quality ratings of graduate departments were those by Cartter[9] and Roose and Andersen[10]. Despite concerns with quality ratings, they correspond well with other indicators, such as quantity of research or even size of department.[11,12] On balance, these ratings appear the best available measure of quality.[13] We have analyzed publication and citation data for our respondents by quality levels of graduate department using the 1969 Roose-Andersen ratings. The results are displayed in Table 8. The general trend is an increasing number of publications and citations as the departmental ratings increase - in physics and for the six fields combined. This is somewhat less the case for dissertation-related publications and citations than for total publications and

TABLE 8 ABOUT HERE

citations. Deviations from this pattern occurred only in sociology and biochemistry with graduates of schools ranked highest producing fewer publications and citations than those of the two categories immediately lower. Overall, quality programs led to graduates with a higher number of publications and citations.

CONCLUSIONS AND IMPLICATIONS FOR THE FUTURE

What answers do we obtain to our initial inquiries? In essence, we find marked support for dissertation practices. The scientific value appears solid as publication and citation tallies stand forth strongly and individual judgments are generally favorable as well. These 1969-70 PhDs looking back consider the dissertation to be valuable training. There does not appear serious conflict between the dissertation aims of producing significant research and providing training for future research. The PhDs in physics, for whom research was the dominant aim in seeking a PhD (median = 4.3 on a 1-5 scale, with teaching a notable secondary aim at median = 3.7) have little proclivity to reduce the current research emphasis in PhD programs. Indeed, as of 1979, after a decade to consider their own doctoral training, these scientists express little inclination to make any substantial changes in the PhD process. Some did offer interesting suggestions, for example:

> "Ph.D. program should be about 4 years from B.S.-Ph.D. with more emphasis on post-doctoral fellowships of, say, 2 years of refine research skills and subspecialize. This suggestion provides more milestones and more convenient drop-out points for the non-academic people."

A plausible sketch emerges of the development of a researcher. Beginning with an intial interest in research, the candidate finds a fruitful dissertation experience aided by a supportive supervisor, possibly leading to early publication experience, then maybe a post-doc. Such factors point toward an enduring research emphasis, at least for a decade. They also suggest possible policy considerations. For instance, one respondent blamed this advisor for not conveying the need for early publication:

> "I feel there was no attempt by the advisor to delve into the question of what I wanted to do - teach - and how to accomplish same - i.e., publish. Alternately, I could have oriented my studies to permit my generating a pile of publications."

A notable observation is that the level of commitment to research drops markedly from the initial post-PhD job (median = 75% time on research) to that nine or ten years later (median = 16%). Two alarming signals emerge from analyzing the research profiles in psychology where we have the benefit of parallel data on 1963-64 PhDs[2] to go with that on the 1969-70 PhDs.[5] First, both cohorts display a tendency to increase the rate of publication for five years or so post-PhD, then to plateau for five years or so, then to show a markedly declining trend. This is consistent with the reduced amount of time devoted to research by the physicists over the decade post-PhD. Second, the 1969-70 psychologists appear considerably less involved in research with a lower rate of publication at the end of their first professional decade than were their 1963-64 fellows. We conclude that scientists should closely monitor the state of research to assure its health.

While physicists' research activity decreases strikingly over time, administrative activity rises. The use of the dissertation research as a practical exercise in management at the project level may be appropriate. The student is faced with the problem of allocating resources and time and dealing with a variety of individuals. One respondent in fact noted:

> "It [the dissertation] forces the candidate to learn how to structure the analysis of the problem; it requires him to find ways to marshall the needed resources for the research and analysis."

While the student typically does not have supervisory responsibilities, the task of deploying resources to complete the dissertation research can be made a more explicit exercise through some rudimentary guidance in research planning, scheduling, resource allocation, and management techniques. Dissertation supervisors might analyze with their students the "ins and outs" of managing academic research groups. Improved preparation for the realities of a physicist's career is certainly a function of graduate education, and the dissertation experience could contribute more than it presently does.

Another potential adjustment would be to begin the dissertation during the middle or later phases of coursework. Beginning the dissertation earlier could lessen the average time of the physics doctoral program - the longest of the six fields surveyed.

Some concern for the relevance of the dissertation was expressed by over half of the respondents. While this may prove difficult to translate into an action item, the message is clear, and quality is not inversely correlated with relevance.

The very large role of faculty preference in the selection of a dissertation topic deserves consideration. This probably relates to two factors: the limited range of expertise, interest, and resources of each faculty member and the limitations set by federal research grants on which four out of five of the 1969-70 PhDs were dependent for support. While such arrangements are generally financially comfortable for students and helpful to faculty members, they seem to favor incremental improvements in existing research programs at the expense of originality. This situation could be aided by an increased emphasis on originality. Good guidance may be a key; as one respondent saw it:

> "Not enough effort is made to help students see the 'big picture' in looking for meaningful research topics, a course in strategic thinking should be included ... "

In sum, the physics PhD dissertation process seemed generally appropriate to a cohort of graduates with a decade of post-PhD experience. Yet, our data show that these PhDs had, on average, distinctly moved away from active research themselves over that time. The dissertation is a staunchly research-oriented endeavor. One can wonder to what extent the commitment to the dissertation/traditional PhD is based on a "research is best" and "everyone should run the gauntlet"ideology that does not fully square with actual career behavior.

ACKNOWLEDGEMENT

We thank our colleagues, especially Daryl Chubin and Dael Wolfle, for their help in this research.

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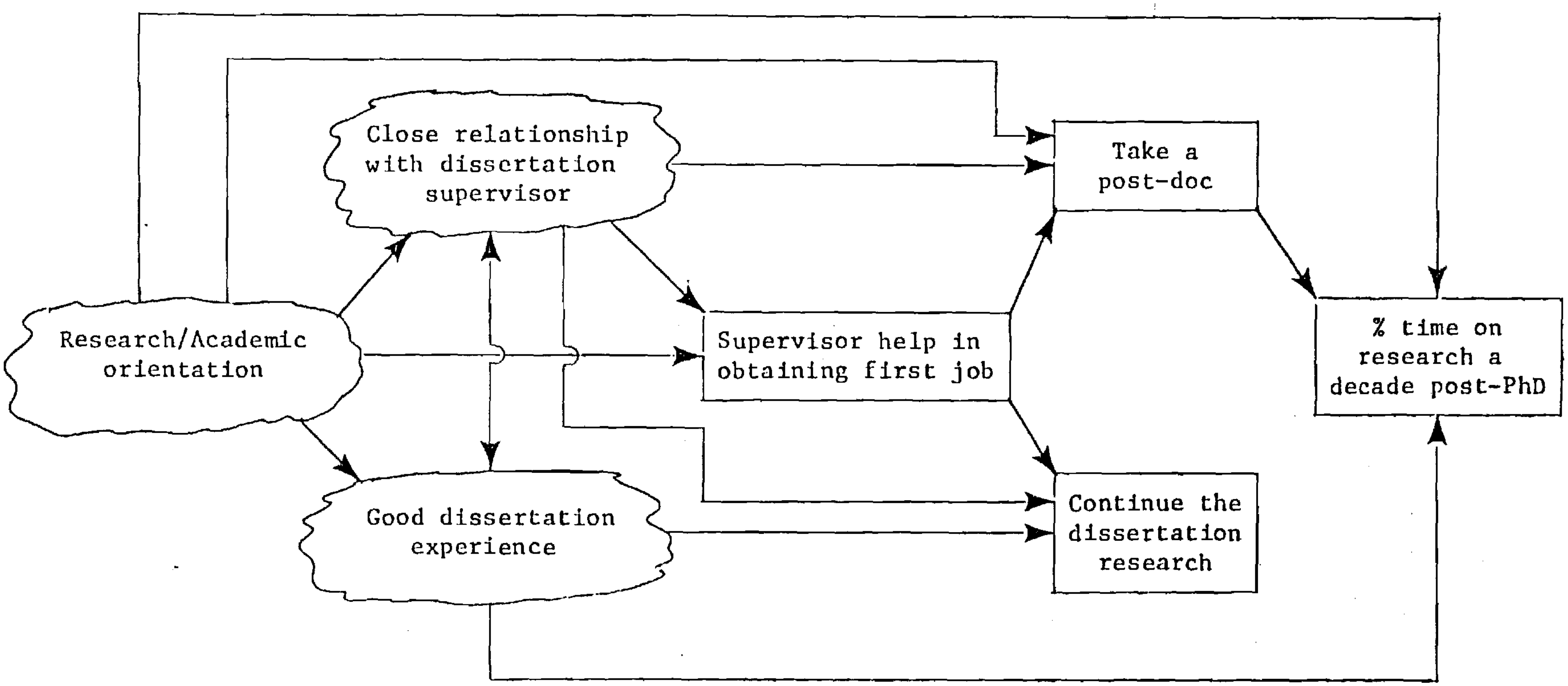
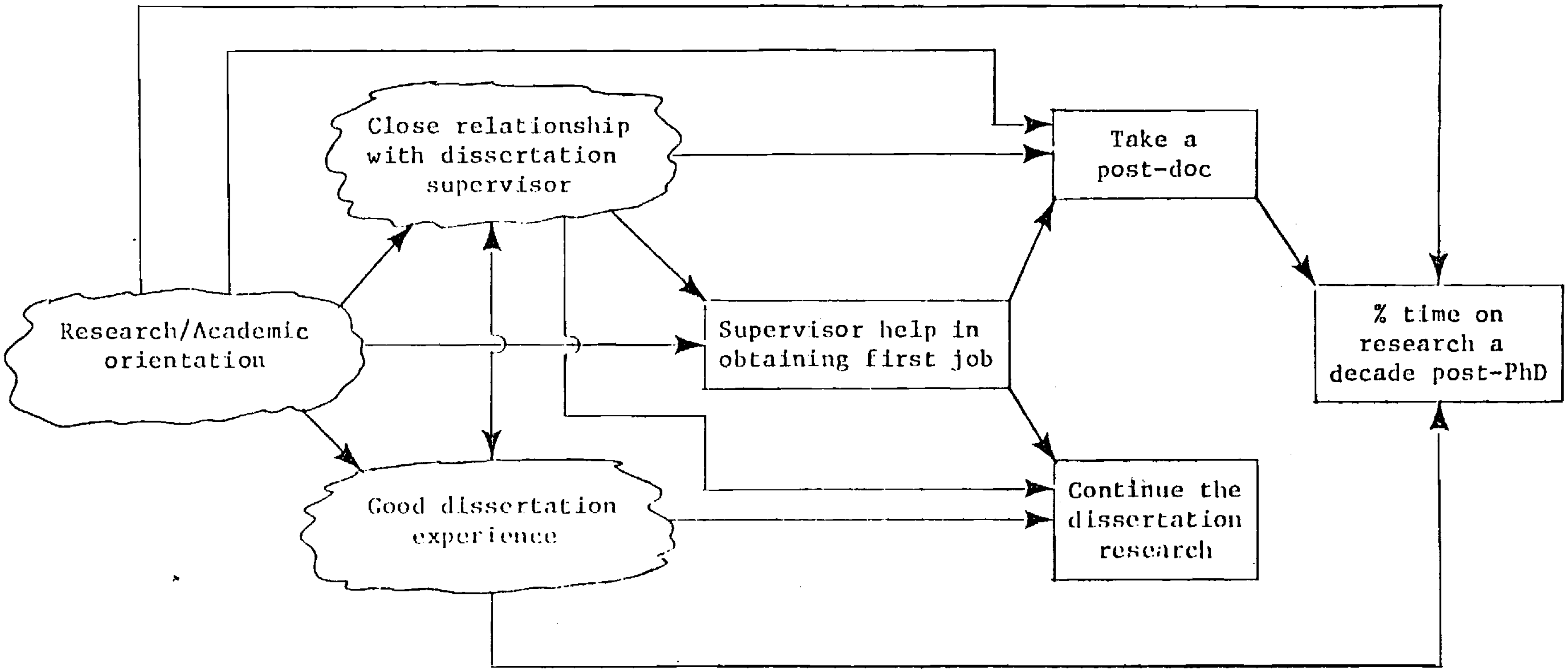

Close relationship with dissertation supervisor
Take a post-doc
Research/Academic orientation
Supervisor help in obtaining first job
% time on research a decade post-PhD
Good dissertation experience
Continue the dissertation research



Close relationship with dissertation supervisor
Take a post-doc
Research/Academic orientation
Supervisor help in obtaining first job
% time on research a decade post-PhD
Good dissertation experience
Continue the dissertation research

TABLE 1

SECTORAL EMPLOYMENT PROFILE - SIX DISCIPLINES

Discipline	Mean Full-time Years Employed Since PhD				Standard Deviation[a]
	Academic	Business	Government	Other	
Physics	4.9	2.6	1.5	0.5	1.7 years
Biochemistry	5.7	1.6	0.9	0.6	2.6
Zoology	8.2	0.3	0.7	0.2	4.5
Electrical Engineering	2.6	5.7	0.9	0.4	2.4
Psychology	5.3	0.7	1.8	1.7	2.4
Sociology	8.6	0.2	0.4	0.5	4.8

[a]Computed about the mean for the academic, business, and government sector means (i.e., standard error of the means).

TABLE 2

PHYSICISTS' PRIMARY WORK ACTIVITY - FIRST JOB AND A DECADE POST-PhD

Primary Work Activity	First Year Post-PhD Job	Decade Post-PhD Job
Research	48.9%	22.1%
Research & Teaching	5.3	12.6
Teaching	27.7	22.1
Development, Design	13.8	12.6
Professional Service (or technical staff not R&D)	3.2	10.5
Administration, Management	0.0	12.6
Administration (Research or Teaching)	0.0	2.1
Other	1.1	5.3

TABLE 3

TIME DEVOTED TO RESEARCH - SIX DISCIPLINES

Discipline	Percentage of Time Devoted to Research		
	First Year Post-PhD Job	Decade Post-PhD Job	Time Decade Post-PhD Job/Time First Job
Physics	58.1%	32.5%	.56
Biochemistry	85.0	57.3	.67
Zoology	43.8	34.7	.79
Electrical Engineering	43.1	24.6	.57
Psychology	26.3	18.7	.71
Sociology	25.5	30.9	1.21

TABLE 4

PHYSICISTS' SUPERVISORY RESPONSIBILITY - FIRST JOB AND JOB A DECADE POST-PhD

Supervisory Responsibilities	First Year Post-PhD Jobs	Decade Post PhD
No Personnel Supervision	53.8%	11.6%
Indirect or Staff Supervision (No line authority)	14.0	21.1
Supervise Students	22.6	20.0
Supervise Team, Unit, Project or Section	8.6	26.3
Manage Major Department or Division	1.1	15.8
General Management of Organization	0.0	5.3

TABLE 5

EVALUATION OF DISSERTATION EXPERIENCES

Aspect Considered	Mean Rating (1 = not satisfactory to 5 = very satisfactory)	
	Physicists	Six Fields Combined
Yielding Valuable Research Findings	3.3	3.3
Learning to Do Independent Research	4.2	4.3
Learning Work-relevant Research Skills	3.6	3.8
Learning Effective Professional Writing	3.5	3.7
Learning Valuable Non-Research Professional Skills	3.3	3.3
Generally Being a Valuable Experience	4.0	4.1

TABLE 6

VIEWS ON CURRENT PRACTICES AND POSSIBLE CHANGES

	Mean Rating	
	(1 = too little to 5 = too much)	
	Physicists	Six Fields Combined
Current dissertation practices in your PhD area:		
--emphasis on originality	2.7	2.7
--emphasis on positive findings	3.3	3.4
--emphasis on relevance	2.2	2.5
	(1 = strongly disapprove to 5 = strongly approve)	
Opinion of the following possible changes in doctoral requirements:		
--overall increase in standards and requirements	3.0	3.1
--several small scale, original research exercises in lieu of the dissertation	2.2	2.2
--dissertation research as at present, but several short reports, more like articles	2.5	2.7
--extended practicum or internship activities to acquire professional skills that are not research-oriented in lieu of the dissertation	2.0	2.2
--alternative doctoral degrees not oriented toward research	2.7	2.6

TABLE 7

PUBLICATIONS AND CITATIONS

	Physicists (N = 88)		Six Fields Combined (N = 593)	
	Mean/Person	(% Publishing)	Mean/Person	(% Publishing)
Publications				
--derived from pre-dissertation research	0.70	(34.1)	0.66	(33.1)
--derived directly from the dissertation	0.89	(60.2)	0.95	(49.9)
--derived from continuation of the dissertation work	0.73	(28.4)	0.79	(26.3)
--post-PhD work not related to the dissertation	5.46	(62.5)	5.33	(62.1)
--total[a]	7.76	(85.6)	8.19	(76.1)
Citations/Publication[b]	Mean/ Publication	(% Cited)	Mean/ Publication	(% Cited)
--derived from pre-dissertation research	5.21	(43.5)	2.74	(34.7)
--derived directly from the dissertation	6.56	(48.7)	4.66	(47.4)
--derived from continuation of the dissertation work	2.98	(42.2)	2.96	(35.0)
--post-PhD work not related to the dissertation	2.07	(30.1)	2.24	(29.8)

[a]Total includes publications for which respondents did not indicate category.

[b]The automated citation counting procedure appears to have undercounted systematically; relative cross-category comparisons should be valid but absolute values are not.

TABLE 8

RATINGS OF PhD DEPARTMENTS vs. PUBLICATIONS AND CITATIONS

Rating	N	Mean Publications/Person	Mean Citations/Person	Mean Publications from Dissertation	Mean Citations from Dissertation
		Physicists			
Strong-Distinguished	13	13.2	59.8	0.8	9.6
Good-Strong	36	9.9	25.2	1.1	5.8
Adequate-Good	29	4.2	12.8	0.8	6.6
Less than Adequate	17	5.1	15.1	0.8	3.0
		All Respondents			
Strong-Distinguished	74	10.0	26.1	1.1	6.2
Good-Strong	224	9.7	24.6	1.1	6.0
Adequate-Good	210	7.0	19.2	0.9	3.2
Less than Adequate	96	5.5	18.0	0.6	2.5

APPENDIX E

Physicists and the Doctoral Dissertation*

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ABSTRACT

This article is based on a recent study of 645 1969-1970 PhD recipients from the disciplines of physics, electrical engineering, biochemistry, zoology, psychology, and sociology. It focuses on the 97 physicists in the sample, studying their personal characteristics, work histories, dissertation experiences and assessment of their worth, and early career productivity including publications and citations. In the process of analyzing the physicists' careers, it compares them as a group with the other disciplinary groups and the sample as a whole. There is general satisfaction with the dissertation experience and little inclination to change its structure. However, the data suggest certain areas where improvement is possible in the dissertation process. These include beginning the dissertation during course work, increasing the relevance and originality of the dissertation, and using the dissertation experience as an opportunity to begin learning research management.

INTRODUCTION

The capstone of the formal education of U.S. physicists is the PhD degree. This degree plays the role of a credential that certifies that its holder is capable of undertaking independent research. This research capability is evidenced primarily by successful completion of the PhD dissertation. Physicists as a group have not been overly critical of the doctoral dissertation, but concern with the form and scope of the dissertation requirement has been expressed in other fields[1,2].

Several serious concerns prompted the present study. Historically, the dissertation has evolved into a research requirement[3] resting on two pillars: that the dissertation produce original and significant <u>scientific contributions</u>, and that it provide <u>training</u> for a research career. These pillars are not necessarily mutually consistent. One could surmise that scientifically fruitful dissertations might not provide felicitous training, or vice versa. Moreover, one can question the research orientation reflected in an Association of American Universities policy statement of 1904 (still held by the Council of Graduate Schools), "The Doctor of Philosophy shall be open as a research degree in all fields of learning, pure and applied." Teaching and professional practice are prominent alternative rationales to seek the PhD.

Even if one accepts the research-oriented PhD and the dissertation requirement as givens, there is the further question of how they may be structured most effectively. This study aimed to provide first-hand evidence of dissertation practice with respect to characteristics that might affect doctoral training outcomes. For instance, one area studied is the balance of evaluative criteria imposed on PhD candidates - originality, significance, positive (confirmatory) results, relevance. There are striking cases that suggest these may not be optimally balanced. As Gabor notes[4]:

> I have been asked more than once why I did not invent the laser. In fact, I have thought of it. In 1950, thinking of the desirability of a strong source of coherent light, I remembered that in 1921, as a young student in Berlin, I had heard from Einstein's own lips his wonderful derivation of Planck's law which postulated the existence of stimulated emission. I then had the idea of the pulsed laser: Take a suitable crystal, make a resonator of it by means of a highly reflecting coating, fill up the upper level by illuminating it through a small hole, and discharge it explosively by a ray of its own light. I offered the idea as a Ph.D. problem to my best student, but he declined it as too risky, and I could not gainsay it, as I could not be sure that we would find a suitable crystal.

This study set out to examine such factors concerning graduate training practices and how they bear on several outcome measures.[5] First, we wanted to examine what satisfaction a cohort of recent PhDs felt toward their dissertation experiences, and what factors most related to this satisfaction. Second, we were interested in whether these graduate training factors predicted early career productivity. Third, we wished to discover opinions regarding several potential changes in doctoral training policies.

THE STUDY

This study focuses on 1969-70 doctoral recipients from six diverse disciplines. It addresses their dissertation, related doctoral training experiences, and their early profesisonal careers in light of this experience. In addition to physics, the disciplines are biochemistry, zoology, electrical engineering, psychology, and sociology. These fields span the National Research Council (NRC) categories of science-based disciplines. A sample of about 400 per field was taken by random draw from 1970 Dissertation Abstracts. The NRC matched this list with their data to eliminate duplicate last names and initials. From those remaining, we randomly selected about 200 per field, to survey in Spring, 1979. Subtracting those to whom we were unable to deliver the questionnaire, we obtained a response rate of 70.0% (645). Our sample of physicists numbered 97, a 64.2% effective response rate. The respondents also offered comments and corrected and expanded our compilation of their career publications (from Science Citation Index - SCI), indicating the relationship of each publication to their dissertations. We later tracked citations to those publications through an Institute of Scientific Information computer search. While non-respondents published slightly less than respondents (mean publications of all respondents 6.46; of non-respondents, 5.96; and of those for whom addresses were not found, 4.81), on essentially all demographic attributes, our sample matched NRC tabulated population attributes closely.

PERSONAL CHARACTERISTICS AND WORK HISTORY OF RESPONDENTS

Among our 97 physicists there were only two women. Physicists were the most homogeneous graduate student population with 93% of those surveyd having a bachelor's degree in physics (the other extreme being sociology at 29%). Median age at the doctorate was 29, for physicists and for the six fields together, with 77% of the physicists being born between 1938 and 1943. The median total time between the bachelor's degree and the doctorate in physics was 6.8 years with the mean being 7.5. That was about the same as zoologists and electrical engineers, about a year longer than biochemists and psychologists, but over two years shorter than sociologists. During the year prior to the PhD, 85% were married while 14% had never married. Both the mean and median number of dependents at this time were two, not counting oneself.

Research interests led physicists' reasons for seeking the PhD (70% rated important), followed by teaching which 54% rated as important (where "important" reflects the respondents rating the particular item 4 or 5 on a

1 to 5 scale from not important to very important). Professional practice, very important in electrical engineering and psychology, was a poor third with 18% rating it important. In this emphasis on research, physicists trailed biochemists (81%) with sociologists lowest of our six field sample at 41%. Teaching was most important to zoologists and sociologists (76%) with electrical engineers (40%) the least academically oriented.

After receiving the PhD, the physicists were employed by a variety of organizations (Table 1). Physicists had a mean full-time equivalent (FTE) academic employment almost twice that in business or industry. Of the six

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TABLE 1 ABOUT HERE
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fields considered, physicists showed the most balanced employment profile across the three sectors. The final column of Table 1 indicates that the standard deviation of physicists from the mean time in academic, business, and government is the lowest of the six groups. Zoologists and sociologists are the least balanced because of their excessive dependence on academia for jobs.

Primary work activity has shifted over the decade since the award of the PhD, as shown in Table 2. Research as the primary activity plummeted

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TABLE 2 ABOUT HERE
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from 49% to 22%. This corresponds with the drop shown in Table 3. The

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TABLE 3 ABOUT HERE
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physicists' decrease in research activity over the decade to 56% of initial activity was the steepest.

Of additional interest is the rise of administration as a primary activity. Table 4 indicates the increase in supervisory responsibility -- note that project, division, and general supervisory responsibility rose from 10 to 47 per-

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TABLE 4 ABOUT HERE
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cent. The increase in administrative responsibility of the electrical engineers closely paralleled that of physicists.[6] The net result of the shifts was a decrease in research activity with a concurrent increase in administrative responsibility - an activity for which the typical PhD does not specifically prepare its graduates.

DISSERTATION EXPERIENCES

With a median of 51 FTE months in the doctoral program, physicists spent the most time of all the disciplines (electrical engineers are lowest with 36 months). Physicists and biochemists spent the longest time on the dissertation itself (counted from the approval of proposal to the completion of the dissertation), median 24 FTE months. The six-field median was 15 months, with psychology lowest at 10 months. There was a bimodal split on when the physicists began their dissertations with "min-coursework" and "after candidacy" being the most common times noted. However, the respondents believed that the dissertation should best begun earlier, in the mid- or later phases of coursework. While only 10% felt that the time spent on the dissertation was too short, 35% felt it was too long, and the majority believed it was just right.

Research assistantships provided the primary means of financial support, both during dissertation research (59%) and writing (55%). Fellowships were second with 19% during the dissertation research and 17% during the dissertation writing. These funds were largely federal in origin as 81% of the physics respondents noted that federal grants were instrumental in the dissertation work, while 41% noted the importance of fellowships or traineeships. The former figure was second only to biochemistry at 89% (six-field mean 62% with sociology low at 27%); while the latter was above only sociology at 33%, with biochemistry again high at 73% (six-field mean 54%). Certainly federal funds for supporting scientific research play a major role in the graduate student's career. Only sociology, which is outside the main interests of the National Science Foundation and the National Institutes of Health, did not have its students heavily supported.

The choice of doctoral program seemed to rest on the balance of several factors. Most important were financial support (64% judged important -- 4 or 5 on a 1 to 5 scale), the reputations of the university (55%) and department (56%), and situational factors (54%). Trailing were reputations of a specialty area within the department (30% important) and of a particular faculty member (27%).

Choice of a dissertation topic also involved balancing a number of factors. Scientific importance was noted as important by 49% of the physicists responding; personal interest, by 56%; manageability, by 47%; environmental considerations, by 44%; and faculty preferences, the most significant, for 65%. Only biochemists at 48% were lower than physicists for personal interest, with zoologists high at 76%. Likewise, only biochemists were higher at 69% for faculty preference than physicists, with psychologists low at 35%. It is not surprising that physicists and biochemists are generally dependent on faculty preferences since they depend overwhelmingly on the availability of support through federally funded projects. Of course, individual differences are pronounced. As one respondent put it: "After a short period of directed reading, I found my own thesis topic"; whereas another reported: "Topics in our research group were essentially assigned by the supervisor."

The character of the physics dissertation was strongly individual rather than collaborative (72% responded 4 or 5 on this 1-5 scale); basic rather than applied (84%); and somewhat bi-modal on a theoretical/ experimental continuum with 20% expressing a theoretical orientation and 68% experimental. These data reinforce the traditional impression of the physics dissertation with the exception that 12% of the respondents note that their work was very highly collaborative. This could reflect the existence of large and well-organized research groups in fields such as high energy physics. A mismatch between such research and completion of dissertations may be building. As one respondent noted: "Experiments in physics generally are becoming much bigger with long lead times - up to 7 years. It is difficult for students to be original in an experiment which involves 25 senior physicists and costs many years." For cross-field comparison, only in electrical engineering did the theoretical and applied orientations dominate.

The rhetoric of the PhD experience emphasizes interaction with and learning from mentors and colleagues. We asked a number of questions regarding supervision and interaction.

Dissertation supervisors tended to be full (61%) or associate (26%) professors. The respondents rated 23% of their dissertation supervisors among the top 5% nationally of scholars in their area of physics while an additional 31% were rated in the next 15%. These ratings appear incongruously inflated until one considers data on the number of other dissertations estimated to have been guided to completion by these supervisors - a median of four and a mean of 10 - indicating that a relatively few professors direct many PhD dissertations. Contrary to the other four fields, physicists and biochemists indicate more productive dissertation experiences when their supervisors had been involved with many other PhDs; this could reflect the reinforcement of large and active labs under the leadership of a dynamic professor.

The amount of supervision varied. Moderate supervision by the dissertation director was recorded by 40%; significant supervision in the initial and final phases, by 20%. The dissertation committees played a minimal and generally passive role with 81% supervising minimally and 10% playing a significant role only at the completion of the dissertation. Little or no serious conflict with supervisors or committees was reported in 94% of the cases. Dissertation supervisors were perceived as stimulating to the student (51% were rated as 4 or 5 on the 5-point scale). One physicist commented: "He [mentor] has had a strong influence in shaping me, both in professional and nonprofessional areas - a very positive force in my life." Only 13% of the committees ranked in the same category. As one respondent phrased it: "Once a dissertation is approved by the advisor, it is 'rubber-stamped' by the others on the committee." Sixty-five percent of the respondents coauthored publications with their supervisors. In 31% of the cases the supervisor played an important role in helping to find their first post-PhD job.

Physicists' perceptions of the importance of various criteria applied in evaluating their own dissertations indicate a strong emphasis on demonstrating research competence (mean = 4.2 on a scale from 1 = not important to 5 = very important) with little emphasis on practical relevance (2.0).

In between, they place originality (3.6), scientific significance (3.6), and positive (confirmatory) findings (3.2). We return to these considerations later in terms of the respondents' perceptions of whether changes in emphasis are desirable.

ASSESSMENT OF THE DISSERTATION EXPERIENCE

Respondents were generally quite satisfied with the dissertation experience, although physicists tend to be slightly less satisfied than our six fields combined (Table 5). There was above average satisfaction with the

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TABLE 5 ABOUT HERE
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value of research findings by 49% of the physicists; learning to do independent research, 79%; learning specific research skills relevant later, 78%; learning to write for publications, 51%; learning other professional skills now valuable, 44%; and as a valuable experience overall, 71%. Satisfaction also extends to other aspects of their graduate training. The choice of dissertation topic gave above average satisfaction to 62% of the respondents; the specific area of training to 65%; the field selected to 71%; the fact of earning a PhD to 84%.

Generally, the physicists approved of current dissertation practices (Table 6). To put the results of Table 6 in somewhat different terms, the

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TABLE 6 ABOUT HERE
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emphasis on originality was believed appropriate by 59% while 29% believed it was slightly underemphasized; the emphasis on positive results was believed appropriate by 70% while 24% thought it was emphasized too much. Only relevance was felt to be underemphasized - by 57% of the respondents while 37% thought it was emphasized appropriately.

The respondents were also asked to consider possible changes in the scope and form of the dissertation (Table 6). Increasing standards produced nearly a Gaussian distribution with 33% in the middle of five categories - neutral. Other possible changes were generally disapproved. The general tenor among physics and other PhDs was to let well enough along; there was little support for change.

EARLY CAREER PRODUCTIVITY: DIFFERENCES AMONG GRADUATES OF DIFFERENT INSTITUTIONS

Prominent features of many scientific careers are publication in the open literature (journal articles, books, book chapters, conference proceedings) and citations to those publications. We examined these with respect to the dissertations of our respondents and as to what factors predicted later publications. These are reasonable, though imperfect, measures of research quantity and quality.[7,8]

Table 7 tallies publication and citation counts through 1978 by research category: pre-dissertation, dissertation, continuation of dissertation post-PhD, and other post-PhD work unrelated to the dissertation.

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TABLE 7 ABOUT HERE
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In general, physics results are very similar to the combined six fields, although the latter figures aggregate some sharp field differences. Dissertations do lead to open literature publications - on average, almost 1/dissertation directly plus anoth .75/continuation of the dissertation research. This distribution is skewed though; combining publication from the dissertation and/or from its continuation shows 34.1% of the physicists and 44.0% of the entire sample not publishing at all in either category (or the .79 publications from continuation for all fields combined reflect efforts of 26.3% of the sample).

Citation counts show that the publications tracing their origins to the dissertation are cited more than other work by these same scientists. A better cross-category comparison is to examine citations/year to take account of the differential time periods available for citation to papers published in different years, and to take logarithms to reduce the weighting placed on those few papers that receive large numbers of citations. On log (citations/year), publications derived from the dissertation directly are cited significantly more than later, non-dissertation-related publications by these same authors for physicists and for the six fields combined. A time profile of when dissertation-derived publications are cited shows a sharp onset for the 1969-70 physics PhDs, peaking in 1972, suggesting that dissertations really are "frontier" science.[5] In sum, dissertations to yield a substantial number of scientifically significant publications, and these are cited slightly more than other work by the same authors.

Interestingly, though not surprising, persons who go on to pursue academic careers (defined here as spending 90% or more of their FTE employment since the PhD in academia, compared to those spending 10% or less) and also those who pursue research careers (defined here as spending 33% or more of their time on research in 1979, compared to those spending 10% or less) produce significantly more publications from dissertations and their continuation. This suggests that what one does with the dissertation bears on one's career.

We have explored a variety of factors concerning the graduate training and related experiences as they may bear on career productivity (e.g., later publications), time devoted to research a decade post-PhD, and other measures, such as salary level and supervisory responsibility.[5] While this is not a clear causal model, we present Figure 1 as a suggestive set of linkages, a cross-field aggregation of some of the associations found.

FIGURE 1 ABOUT HERE

The gist is that where one set forth with an interest in research and/or teaching, benefited from a favorable dissertation experience and a helpful relationship with one's mentor, and pursued post-dissertation research, an enduring commitment to research was nurtured.

In a series of multiple regressions, we examined predictors of career attainments by field and for various aggregations of the combined sample (e.g., academics, researchers).[5] In sum, early publications and percent time on research on the first post-PhD job are the best predictors of later publications and citations, with post-doctoral appointments and the prestige of the PhD-granting department also effective predictors. The only consistent salary predictor was in the negative direction - taking a post-doc.

We now consider the prestige of the PhD-granting department as a dominant predictor of later citations for the physicists and a measure pertinent to certain policy decisions (such as a prospective doctoral student's choice of department and the federal government's support strategies).

Among the most noted overall quality ratings of graduate departments were those by Cartter[9] and Roose and Andersen[10]. Despite concerns with quality ratings, they correspond well with other indicators, such as quantity of research or even size of department.[11,12] On balance, these ratings appear the best available measure of quality.[13] We have analyzed publication and citation data for our respondents by quality levels of graduate department using the 1969 Roose-Andersen ratings. The results are displayed in Table 8. The general trend is an increasing number of publications and citations as the departmental ratings increase - in physics and for the six fields combined. This is somewhat less the case for dissertation-related publications and citations than for total publications and

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TABLE 8 ABOUT HERE
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citations. Deviations from this pattern occurred only in sociology and biochemistry with graduates of schools ranked highest producing fewer publications and citations than those of the two categories immediately lower. Overall, quality programs led to graduates with a higher number of publications and citations.

CONCLUSIONS AND IMPLICATIONS FOR THE FUTURE

What answers do we obtain to our initial inquiries? In essence, we find marked support for dissertation practices. The scientific value appears solid as publication and citation tallies stand forth strongly and individual judgments are generally favorable as well. These 1969-70 PhDs looking back consider the dissertation to be valuable training. There does not appear serious conflict between the dissertation aims of producing significant research and providing training for future research. The PhDs in physics, for whom research was the dominant aim in seeking a PhD (median = 4.3 on a 1-5 scale, with teaching a notable secondary aim at median = 3.7) have little proclivity to reduce the current research emphasis in PhD programs. Indeed, as of 1979, after a decade to consider their own doctoral training, these scientists express little inclination to make any substantial changes in the PhD process. Some did offer interesting suggestions, for example:

> "Ph.D. program should be about 4 years from B.S.-Ph.D. with more emphasis on post-doctoral fellowships of, say, 2 years of refine research skills and subspecialize. This suggestion provides more milestones and more convenient drop-out points for the non-academic people."

A plausible sketch emerges of the development of a researcher. Beginning with an intial interest in research, the candidate finds a fruitful dissertation experience aided by a supportive supervisor, possibly leading to early publication experience, then maybe a post-doc. Such factors point toward an enduring research emphasis, at least for a decade. They also suggest possible policy considerations. For instance, one respondent blamed this advisor for not conveying the need for early publication:

> "I feel there was no attempt by the advisor to delve into the question of what I wanted to do - teach - and how to accomplish same - i.e., publish. Alternately, I could have oriented my studies to permit my generating a pile of publications."

A notable observation is that the level of commitment to research drops markedly from the initial post-PhD job (median = 75% time on research) to that nine or ten years later (median = 16%). Two alarming signals emerge from analyzing the research profiles in psychology where we have the benefit of parallel data on 1963-64 PhDs[2] to go with that on the 1969-70 PhDs.[5] First, both cohorts display a tendency to increase the rate of publication for five years or so post-PhD, then to plateau for five years or so, then to show a markedly declining trend. This is consistent with the reduced amount of time devoted to research by the physicists over the decade post-PhD. Second, the 1969-70 psychologists appear considerably less involved in research with a lower rate of publication at the end of their first professional decade than were their 1963-64 fellows. We conclude that scientists should closely monitor the state of research to assure its health.

While physicists' research activity decreases strikingly over time, administrative activity rises. The use of the dissertation research as a practical exercise in management at the project level may be appropriate. The student is faced with the problem of allocating resources and time and dealing with a variety of individuals. One respondent in fact noted:

> "It [the dissertation] forces the candidate to learn how to structure the analysis of the problem; it requires him to find ways to marshall the needed resources for the research and analysis."

While the student typically does not have supervisory responsibilities, the task of deploying resources to complete the dissertation research can be made a more explicit exercise through some rudimentary guidance in research planning, scheduling, resource allocation, and management techniques. Dissertation supervisors might analyze with their students the "ins and outs" of managing academic research groups. Improved preparation for the realities of a physicist's career is certainly a function of graduate education, and the dissertation experience could contribute more than it presently does.

Another potential adjustment would be to begin the dissertation during the middle or later phases of coursework. Beginning the dissertation earlier could lessen the average time of the physics doctoral program - the longest of the six fields surveyed.

Some concern for the relevance of the dissertation was expressed by over half of the respondents. While this may prove difficult to translate into an action item, the message is clear, and quality is not inversely correlated with relevance.

The very large role of faculty preference in the selection of a dissertation topic deserves consideration. This probably relates to two factors: the limited range of expertise, interest, and resources of each faculty member and the limitations set by federal research grants on which four out of five of the 1969-70 PhDs were dependent for support. While such arrangements are generally financially comfortable for students and helpful to faculty members, they seem to favor incremental improvements in existing research programs at the expense of originality. This situation could be aided by an increased emphasis on originality. Good guidance may be a key; as one respondent saw it:

> "Not enough effort is made to help students see the 'big picture' in looking for meaningful research topics, a course in strategic thinking should be included ... "

In sum, the physics PhD dissertation process seemed generally appropriate to a cohort of graduates with a decade of post-PhD experience. Yet, our data show that these PhDs had, on average, distinctly moved away from active research themselves over that time. The dissertation is a staunchly research-oriented endeavor. One can wonder to what extent the commitment to the dissertation/traditional PhD is based on a "research is best" and "everyone should run the gauntlet"ideology that does not fully square with actual career behavior.

ACKNOWLEDGEMENT

We thank our colleagues, especially Daryl Chubin and Dael Wolfle, for their help in this research.

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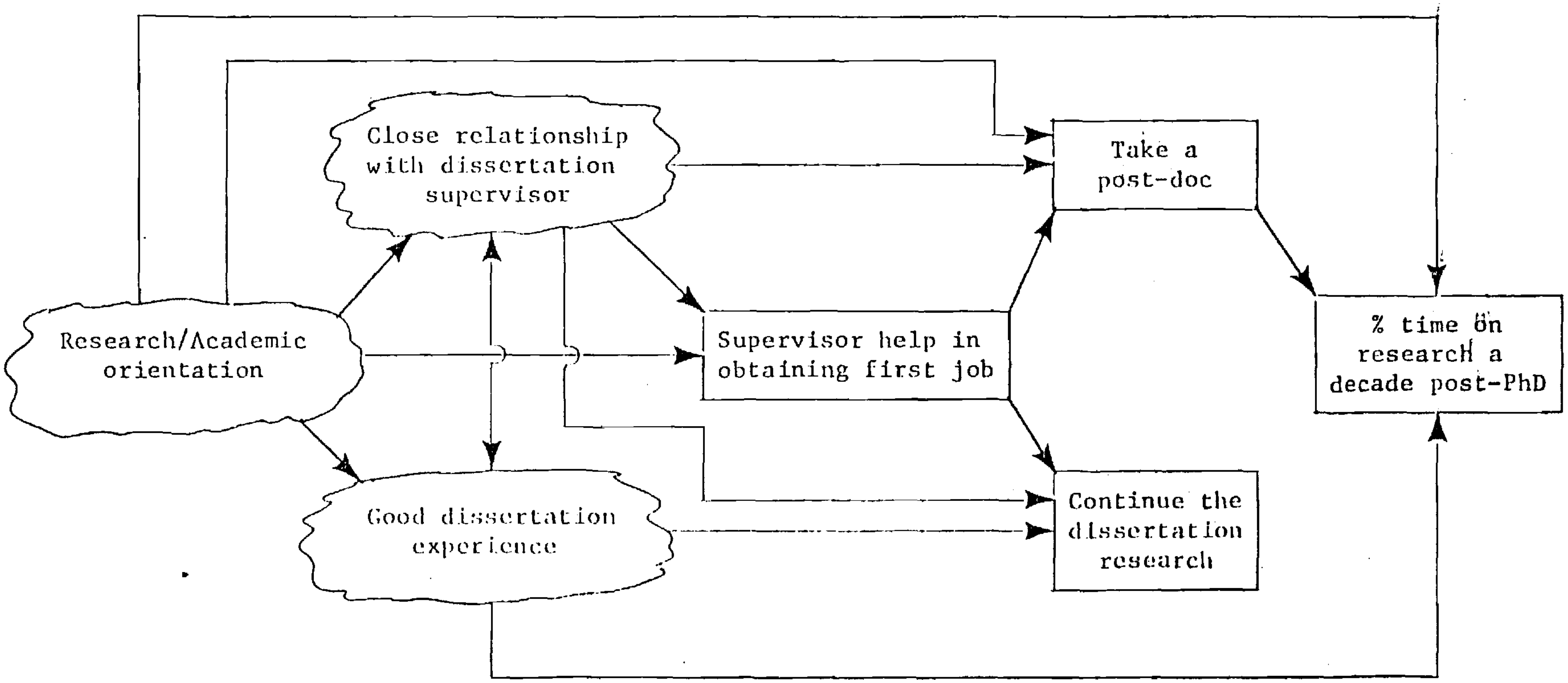
Close relationship with dissertation supervisor
Take a post-doc
Research/Academic orientation
Supervisor help in obtaining first job
% time on research a decade post-PhD
Good dissertation experience
Continue the dissertation research

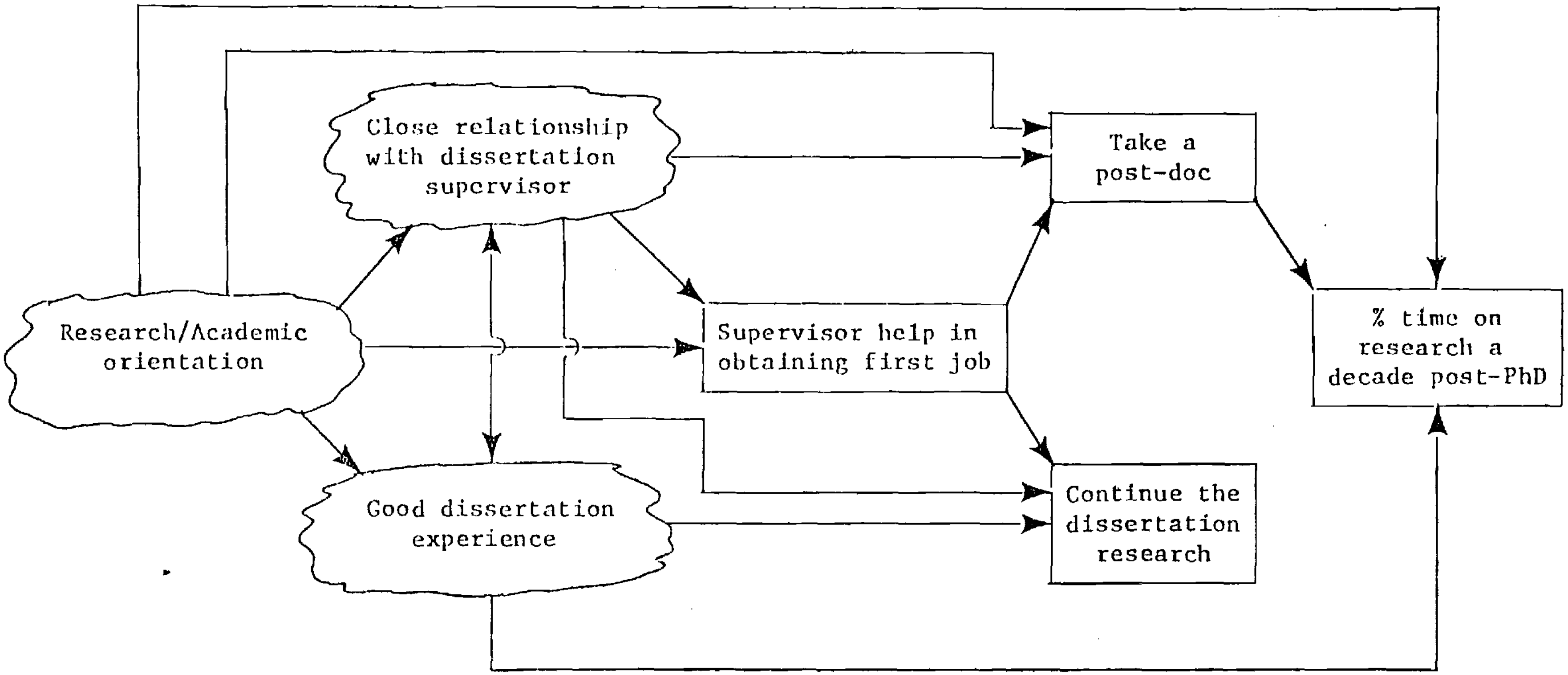
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TABLE 1

SECTORAL EMPLOYMENT PROFILE - SIX DISCIPLINES

Discipline	Mean Full-time Years Employed Since PhD				Standard Deviation[a]
	Academic	Business	Government	Other	
Physics	4.9	2.6	1.5	0.5	1.7 years
Biochemistry	5.7	1.6	0.9	0.6	2.6
Zoology	8.2	0.3	0.7	0.2	4.5
Electrical Engineering	2.6	5.7	0.9	0.4	2.4
Psychology	5.3	0.7	1.8	1.7	2.4
Sociology	8.6	0.2	0.4	0.5	4.8

[a]Computed about the mean for the academic, business, and government sector means (i.e., standard error of the means).

TABLE 2

PHYSICISTS' PRIMARY WORK ACTIVITY - FIRST JOB AND A DECADE POST-PhD

Primary Work Activity	First Year Post-PhD Job	Decade Post-PhD Job
Research	48.9%	22.1%
Research & Teaching	5.3	12.6
Teaching	27.7	22.1
Development, Design	13.8	12.6
Professional Service (or technical staff not R&D)	3.2	10.5
Administration, Management	0.0	12.6
Administration (Research or Teaching)	0.0	2.1
Other	1.1	5.3

TABLE 3

TIME DEVOTED TO RESEARCH - SIX DISCIPLINES

Discipline	Percentage of Time Devoted to Research		
	First Year Post-PhD Job	Decade Post-PhD Job	Time Decade Post-PhD Job/Time First Job
Physics	58.1%	32.5%	.56
Biochemistry	85.0	57.3	.67
Zoology	43.8	34.7	.79
Electrical Engineering	43.1	24.6	.57
Psychology	26.3	18.7	.71
Sociology	25.5	30.9	1.21

TABLE 4

PHYSICISTS' SUPERVISORY RESPONSIBILITY - FIRST JOB AND JOB A DECADE POST-PhD

Supervisory Responsibilities	First Year Post-PhD Jobs	Decade Post PhD
No Personnel Supervision	53.8%	11.6%
Indirect or Staff Supervision (No line authority)	14.0	21.1
Supervise Students	22.6	20.0
Supervise Team, Unit, Project or Section	8.6	26.3
Manage Major Department or Division	1.1	15.8
General Management of Organization	0.0	5.3

TABLE 5

EVALUATION OF DISSERTATION EXPERIENCES

Aspect Considered	Mean Rating (1 = not satisfactory to 5 = very satisfactory)	
	Physicists	Six Fields Combined
Yielding Valuable Research Findings	3.3	3.3
Learning to Do Independent Research	4.2	4.3
Learning Work-relevant Research Skills	3.6	3.8
Learning Effective Professional Writing	3.5	3.7
Learning Valuable Non-Research Professional Skills	3.3	3.3
Generally Being a Valuable Experience	4.0	4.1

TABLE 6

VIEWS ON CURRENT PRACTICES AND POSSIBLE CHANGES

	Mean Rating (1 = too little to 5 = too much) Physicists	Six Fields Combined
Current dissertation practices in your PhD area:		
--emphasis on originality	2.7	2.7
--emphasis on positive findings	3.3	3.4
--emphasis on relevance	2.2	2.5
	(1 = strongly disapprove to 5 = strongly approve)	
Opinion of the following possible changes in doctoral requirements:		
--overall increase in standards and requirements	3.0	3.1
--several small scale, original research exercises in lieu of the dissertation	2.2	2.2
--dissertation research as at present, but several short reports, more like articles	2.5	2.7
--extended practicum or internship activities to acquire professional skills that are not research-oriented in lieu of the dissertation	2.0	2.2
--alternative doctoral degrees not oriented toward research	2.7	2.6

TABLE 7

PUBLICATIONS AND CITATIONS

	Physicists (N = 88)		Six Fields Combined (N = 593)	
	Mean/Person	(% Publishing)	Mean/Person	(% Publishing)
Publications				
--derived from pre-dissertation research	0.70	(34.1)	0.66	(33.1)
--derived directly from the dissertation	0.89	(60.2)	0.95	(49.9)
--derived from continuation of the dissertation work	0.73	(28.4)	0.79	(26.3)
--post-PhD work not related to the dissertation	5.46	(62.5)	5.33	(62.1)
--total[a]	7.76	(85.6)	8.19	(76.1)
Citations/Publication[b]	Mean/ Publication	(% Cited)	Mean/ Publication	(% Cited)
--derived from pre-dissertation research	5.21	(43.5)	2.74	(34.7)
--derived directly from the dissertation	6.56	(48.7)	4.66	(47.4)
--derived from continuation of the dissertation work	2.98	(42.2)	2.96	(35.0)
--post-PhD work not related to the dissertation	2.07	(30.1)	2.24	(29.8)

[a] Total includes publications for which respondents did not indicate category.

[b] The automated citation counting procedure appears to have undercounted systematically; relative cross-category comparisons should be valid but absolute values are not.

TABLE 8

RATINGS OF PhD DEPARTMENTS vs. PUBLICATIONS AND CITATIONS

Rating	N	Mean Publications/Person	Mean Citations/Person	Mean Publications from Dissertation	Mean Citations from Dissertation
		Physicists			
Strong-Distinguished	13	13.2	59.8	0.8	9.6
Good-Strong	36	9.9	25.2	1.1	5.8
Adequate-Good	29	4.2	12.8	0.8	6.6
Less than Adequate	17	5.1	15.1	0.8	3.0
		All Respondents			
Strong-Distinguished	74	10.0	26.1	1.1	6.2
Good-Strong	224	9.7	24.6	1.1	6.0
Adequate-Good	210	7.0	19.2	0.9	3.2
Less than Adequate	96	5.5	18.0	0.6	2.5

APPENDIX F

THE DOCTORAL DISSERTATION IN THE BIOSCIENCES

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Alan L. Porter

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ABSTRACT

Recently, the traditional approach to doctoral training and the value of the dissertation have come under scrutiny. This paper presents an assessment based on a cohort of 1969-70 bioscience PhDs of the doctoral training process and the dissertation in terms of their contribution to career development and research productivity.

Introduction

The PhD degree is a prerequisite for advancement in academia and valued in most research settings. Although there is tremendous diversity in the characteristics of PhD programs, one uniformity is the required completion of an original piece of work embodied in the doctoral dissertation. The dissertation is the final achievement of the doctoral candidate and its completion signals that the new PhD is capable of conducting original, scholarly work.

Traditionally the doctoral dissertation has had two major functions: one scholarly and one educational. The former function stems from the commonly accepted notion that the dissertation makes a positive, original, and even significant contribution to knowledge in the discipline. The latter stems from the notion that the dissertation experience provides training in research and scholarly techniques which prepare the doctoral student for a career of productive research.

With shrinking prospects for academic jobs in most disciplines (Braddock 1978), the traditional approach to training the graduate student is being reexamined (Behnke 1977), and the importance of the dissertation to graduate education and a scientist's career, whether academic or not, is being challenged. Writing with specific reference to biologists, Reid (1978) presents five criticisms of the traditional dissertation: 1) it is not a useful tool in scientific communication; 2) it is a poor educational tool; 3) it places an undue burden on the doctoral student; 4) it is not evaluated by widely accepted standards; and 5) frequently, it generates no publications, even if of high quality. These concerns challenge the utility of the dissertation to perform the two traditional functions. In fact, Reid suggests that writing the dissertation might be dysfunctional for the student since biologists tend to publish short journal articles and not extended monographs. Although he does acknowledge that the dissertation frequently serves as an information source for later publication, Reid argues that writing the dissertation may place a burden on the graduate student and convey an incorrect impression of normal scholarly work in the field. These concerns derive from an academic perspective; the pertinence of the dissertation to those who will pursue nonacademic research careers is even more problematic.

How can one test such assertions? True experimental comparisons are not available. Our approach to explore, if not test, these assertions is basically two-fold. We define a sample of PhDs who have had about a decade of post-PhD experience to establish their career directions. We then gauge research effectiveness of their dissertations in terms of the open literature publications generated and the rate of citations which those publications accrue. As for training effectiveness, we simply ask the PhDs for their retrospective perceptions on a number of dissertation features. As a sidenote, we also discuss doctoral training with a small sample of "ABDs" (persons who have completed all PhD requirements except the dissertation before leaving graduate programs).

These issues, and others, are addressed in a cross-disciplinary study of the role of the doctoral dissertation in career productivity that examines a sample of doctorate holders in six scientific disciplines (Porter et al. 1981). The sample consists of 1969-70 doctorates queried in Spring, 1979. This paper focuses on data from zoologists and biochemists included in the larger study; the other disciplines are physics, electrical engineering, psychology, and sociology.

We conceive of the preparation of a doctoral level scientist as a process. Certain initial states (e.g., career aims) and structural features of a graduate program (both tangible, e.g., research facilities, and intangible, e.g., rated quality of the department) set the stage. The training process then unfurls leading on to certain critical early career choices. The paper follows such a conceptual framework as it discusses 1) sample characteristics, 2) graduate training and dissertation experiences; 3) work history, 4) personal assessments of dissertation practices, and 5) recommendations for change. Comparisons with the other disciplines in the study are made where appropriate.

Study Design and Sample Characteristics

A random sample of 155 zoologists and 156 biochemists listed in Dissertation Abstracts in 1970 were sent questionnaires concerning their graduate training and dissertation experience.[1] The response rate was 79.4% for zoologists and 76.3% for biochemists, yielding 123 and 119 usable responses respectively. The sample matches National Research Council Profiles closely on all comparable characteristics except that women are under-represented in our sample of zoologists.[2] The mean age of the zoologists at the time of the doctorate was 31; median age, 29. Biochemists were younger with a mean age of 29 and a median of 27. Median total time from bachelor's to doctorate was 6.6 years for zoologists and 5.5 years for biochemists (median for all six fields was 6.0 years). Almost 79% of the zoologists and 77% of the biochemists were married at the time of the doctorate.

The Doctoral Training Process

Table 1 highlights the observations of these 1969-70 PhDs on their graduate training experiences, as recorded with the "hindsight" of 1979. With respect to aims in seeking a PhD, zoologists favor teaching somewhat over research; biochemists, the converse. Professional practice (not shown) is a very poor third influence (respective means 1.8 and 2.0 on the 5-point scale).

No single factor dominated the process of selecting a PhD program. Most interesting, perhaps, is the zoologists' consideration of a particular intended "mentor" as a factor in choosing a program (46% responded "very important, 5 on the 5-point scale), to a degree unmatched in any of the other fields surveyed (mean of the other five fields, 2.5). When combined with the zoologists' emphasis on specialty area strength, it appears that they have a relatively clear focus in mind from the beginning of their graduate education.

Table 1 about here

Peer ratings of the PhD-granting departments show that fewer than 10% attended elite departments; most of these PhDs graduated from mid-ranked ones. Prestige of department predicts later research activity significantly. For instance, for the six fields combined, those graduating from the two highest ranked categories generated 10.0 and 9.7 mean career publications, versus 6.9 and 5.5 for the lower ranked categories.

Research facilities for the dissertation are rated very favorably, considerably better than 1979 facilities. This reflects, at least in part, a cascade effect as persons move out to less endowed institutions; it is seen for all the fields studied.

Time devoted to doctoral training presents some interesting contrasts. Biochemistry, of the six fields, shows the least elapsed time from bachelor's to doctorate, but is second only to physics in time spent in the doctoral program - implying that students tend to enter directly into graduate school. Both biochemists and zoologists devote almost half of the doctoral time to the dissertation, yet they feel that this is just about the right amount to spend (over 70% in each field so indicated). Almost half the respondents began work on the dissertation early in their course work. Respondents indicated remarkable agreement between the actual and an ideal allocation of time to various facets, with data gathering the dominant component (42% of the time for the zoologists; 46% for the biochemists). While the natural scientists spent nearly two years on the dissertation, compared to about one year (9.5 to 12.3 FTE months) for the social scientists and engineers, they do not see it as an undue burden in this regard.

Federal aid was extremely important in the support of these scientists as graduate students. Reductions in available support could severely impede the training process. For instance, sociology, with the least federal support, showed by far the longest elapsed time from bachelor's to doctorate (median 9.1 years).

Factors in the choice of a dissertation topic are of concern as a key step in research training and as a gauge of student independence. Results suggest that the average zoology student had a great deal of autonomy in the selection of a dissertation topic in that personal interest and perceived importance were their two strong determinants. Indeed, comparing across fields finds zoologists highest in rating personal choice important and very low in faculty influence. In contrast, biochemists rated faculty preference as the most important factor in the choice of a dissertation topic. They are highest across fields in this regard and lowest in rating personal interest important. In areas where the "lab" greatly affects choice of topics, early exposure (as by "rotation" wherein students spend a month in various labs before deciding on an advisor) makes sense. One respondent commented that this strategy was "tremendously broadening and helpful."

The apprentice-like relationship of student to mentor suggests that the dissertation supervisor can be a dominant influence. Indeed, comments by the successful PhDs often noted special support, whereas lack of a good relationship with supervisor and committee was (along with financial exigencies) the most mentioned reason for ABDs not completing their doctorates (44% so indicated on each item, where multiple responses were accepted).[3] As indicated in Table 1, supervisors were perceived to be extraordinarily eminent (68% in zoology and 55% in biochemistry were categorized among the top 20% nationally) and prolific in the numbers of dissertations guided. This suggests that PhD students concentrate with a relatively few mentors. While these mentors are found to be accessible and inspirational, the same cannot be said for dissertation guidance committees. "Minimal" supervision was the norm in both fields and the degree of inspiration/stimulation was low (means of 2.7 in zoology and 2.2 in biochemistry). On the other hand, it is reassuring to report that serious conflict among student, supervisor, and/or committee was rare.

These PhDs perceived that their own dissertations were evaluated on multiple criteria. Besides those noted in Table 1, general demonstration of research competence was generally important, while practical relevance was not. We return to such considerations after addressing research development in terms of dissertation outputs and early career patterns.

Indicators of Scientific Merit of Dissertations

One of our central questions was whether the dissertation constituted a significant scientific contribution or simply a training exercise. To address this issue we tallied publications and citations attributable directly to the dissertation research and (separately) to its continuation post-PhD.

A majority of the zoologists (71%) and biochemists (75%) publish from their dissertation, more so than the other fields examined. In addition, more publications per dissertation were produced by the bioscientists than by any other discipline: an average of 1.49 per biochemist and 1.37 per zoologist compared with 0.95 per scientist in the entire sample. The bioscientists are also most prolific in publishing from continuation of the dissertation work with biochemists averaging 0.97 publications per person and zoologists 1.31. The bioscientists continue to be most prolific over the first professional decade - biochemists with a mean of 12.34 publications (median 10.33; 92.4% publishing at least once), zoologists 9.72 (median 8.14; 82.1% publishing), versus the mean of six fields of 8.19 (median 5.03; 76.1% publishing).

Another endorsement of the scientific merit of the dissertation research comes in terms of the frequency of citation. Publications identified as deriving from the dissertation are cited most frequently (means of 7.9 for biochemists, 2.1 for zoologists, 4.7 for all six fields), followed by those which respondents identify with continuation of the dissertation work (6.9, 1.4, 3.0, respectively), pre-dissertation research (6.2, 1.3, 2.7) and post-PhD work not related to the dissertation (3.6, 1.4, 2.2). We also consider citations/year because of the unequal time intervals since publication in which citation could occur and take logarithms to reduce the weighting accruing to those few publications that are very heavily cited. Even on this measure, dissertation-derived publications are most cited (for six fields, ANOVA yields an $\underline{F} = 4.86$, $p < .002$). Within field comparisons for biochemistry and zoology show the same ordering, but differences between dissertation-derived and later publications are not statistically significant.

In sum, dissertations do lead to significant numbers of open literature publications, and those publications are cited at least as heavily as other work by these same scientists.

Early Scientific Careers

Transitioning from graduate school to professional employment warrants careful consideration in several regards. For one, it is interesting to ascertain to what extent there is research continuity. In terms of continued work on the dissertation, 32% of the zoologists and only 14% of the biochemists report carrying the dissertation work forward after completion of the doctorate (see also Table 2). The difference may be due in part to the zoologists' selecting dissertation topics of personal interest while the biochemists chose topics of interest to their professors. Both zoologists and biochemists report the dissertation as moderately relevant to their work activity on the first job, and slightly less so to the job at the time of the survey.

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Table 2 about here
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An important distinction among fields is the degree of reliance on post-doctorate appointments. As per Table 2, these are the mode for biochemists and also quite popular in zoology. Of the other fields examined, only physics is close to the biosciences in the popularity of post-doctorates (40%); followed by psychology (26%), sociology (18%), and electrical engineering (10%). The strong place of research in biochemists' first position is consistent with the number of post-doctorates taken.

Research plays a strong role through the first decade of these bioscientists. It is interesting to note, however, the increasing commitment to teaching and the budding move into administration evidenced some 9-10 years post-PhD. One might wonder as to the relevance of PhD training to these roles. Again, it is helpful to place these findings into context by noting that biochemists and, especially, zoologists predominantly work in academia. The dual commitment of these bioscientists to research and academic setting come closer to the traditional image of the scientific career than do the other fields examined. As such, PhD training may well find a better fit with their needs than with those in some other sciences and engineering.

Perceptions of Dissertation Experiences and of Potential Changes

Respondents evaluated their own dissertation experience on a number of factors, as presented in the first section of Table 3. The general

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Table 3 about here
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impression is really quite favorably for all aspects of the experience. Two aspects stand out, however, as being particularly satisfying. One is learning how to do independent research, and the other is the feeling that it was a valuable experience in general. Both these responses could reflect the training function of the dissertation to the degree that the general feeling of a valuable experience translates into a sense of confidence and ability to perform as a professional. On a composite index (Table 3, items 3-6 equally weighted) to measure the training value of the dissertation, zoologists score the highest (4.0) of any field with biochemists (3.9) also scoring above the overall average of 3.8.

Respondents' evaluations of current dissertation practices are presented in the second section of Table 3. The average response indicates that, as a group, zoologists and biochemists are well satisfied with current emphases in doctoral programs. Occasionally, the originality requirement can hurt, as one biochemist described it:

> I worked for four years on a dissertation project which was ultimately rejected because it was "scooped . . ." I would strongly suggest that safeguards against such incredible waste and humiliation be incorporated into PhD programs.

However, we we see in the third section of Table 3, recommendations for change in doctoral requirements generally meet with disapproval, with the exception of a recommendation for increased standards (slight support). One zoologist suggested at the end of our listing of proposed changes: "At this point we might as well list them in the Sears and Roebuck catalogue."

Having hypothesized that the dissertation would stand strongly on its research merits and be well thought of for research training, we were supported by the study findings. However, we anticipated that the dissertation and associated PhD requirements would not be evaluated favorably by those PhDs not oriented to research. To probe this possibility, we partitioned the respondents into two groups

- --those reporting 33% or more of current work time devoted to research (54 zoologists, 86 biochemists)
- --those reporting 10% or less of work time devoted to research (43 zoologists, 22 biochemists).

The National Science Foundation (1981) reports 33% as an average time commitment to research; 10% was an arbitrary cutting point. (Because our bioscience sample is so heavily academic, we did not pursue the academic/non-academic distinction, although we perceive that to be an important factor as fewer PhDs go into academia - National Science Board, 1979.)

Certain interesting comparisons emerge, suggesting associations between graduate training experience and career directions [unless otherwise noted, items scaled from 1 = not important/satisfactory to 5 = very important/satisfactory]:

--As one would suspect, researchers view their dissertation as a slightly more valuable experience; the more surprising finding is that non-researchers are decidedly positive as well (4.49 for non-researchers - NR - vs. 4.52 for researchers - R - in zoology - Z; 3.86 vs. 4.36 in biochemistry - B);

--Research-oriented bioscientists attended departments with slightly better-rated graduate faculties on average (2.85 NRZ vs. 3.09 RZ; 2.62 NRB vs. 3.02 RB);

--Federal aid in graduate training is somewhat associated with a research-oriented career (e.g., for fellowship support, ratings show 2.49 NRZ vs. 3.55 RZ; 3.67 NRB vs. 4.02 RB).

--Dissertation topic choices relate to career paths, especially for zoologists (e.g., manageability as a factor rates 3.28 NRZ vs. 2.43 RZ; 2.82 NRB vs. 2.62 RB);

--Those whose dissertations met more stringent evaluations were more apt to pursue research-oriented careers (e.g., scientific significance rated 3.50 NRZ vs. 3.96 RZ; 3.27 NRB vs. 3.71 RB).

--Post-doctoral appointments (1.65 NRZ vs. 3.52 RZ; 3.36 NRB vs. 4.29 RB) and continuation of the doctoral research (2.28 NRZ vs. 3.07 RZ; 1.52 NRB vs. 2.15 RB) associate with research activity a decade after the PhD.

Non-researchers tended to be essentially as satisfied as researchers with perceived dissertation requirements. While biochemistry non-researchers were significantly more favorably disposed toward a possible change to several small-scale projects in lieu of a dissertation, or extended practicum experience in lieu of it, neither they nor their zoologist counterparts offered any real support for such major changes (all ratings neutral or below, except on tightening standards). Simply, there does not appear to be a constituency for change in the dissertation requirements among PhD bioscientists.

Concluding Observations

Given the data presented, we are in a position to consider some of the criticisms levied at the traditional dissertation by Reid and others. One emergent impression is that the dissertation serves its training function well. The respondents felt that the dissertation experience had taught them how to do independent research. In addition, the dissertation was quite relevant (especially for zoologists) both on the first post-PhD job and on the current job. Individuals raised a number of interesting concerns. For instance, a zoologist asserted that "a person ought to have a breadth of knowledge." A biochemist added: "Graduate work today I find far too highly specialized. We are turning out miniature idiot-savants." In a succinct call for interdisciplinary interactions, another noted:

> Graduate training remains insulated from the outside world. After six years of graduate study all students know what the big research plums are, but only a few have the foggiest notion about what sort of information the world needs. Related disciplines are ludicrously isolated in the university.

Although it may be true that the dissertation itself is not a useful tool in scientific communication, it can serve as a repository of ideas and results for later publications. Reid, in fact, substantiates this point, as do we. In addition, the dissertation can be the springboard for continuing work in the area. Respondents also indicated that the dissertation taught them how to write for scholarly publications. Although the monograph form of the dissertation may not be what is published in the field, the dissertation can be a vehicle for learning about organization of ideas and alternative modes of expressing them - important characteristics of good writing. Finally, our data show that publications do flow directly from the dissertation, and these publications are selectively highly cited.

The experience of our sample was that the dissertation is a useful educational tool. It is valued as a means of learning to conduct original research as well as an aid in learning how to write. One biochemist noted:

> The experience of developing/applying technology and theory to a specific problem has been invaluable in my subsequent career as a basic researcher in a clinical field. Systematic approach to problems and knowledge of available techniques has given me a great advantage over M.D.-trained colleagues who attempt such research.

(But another commented: "Should have gotten M.D., could do same work at living wage.")

Respondents did not perceive the dissertation as an undue burden and, in fact, were inclined toward raising standards for obtaining the PhD. The idea of changing the nature of the dissertation research met with disapproval. Most surprising was that the ABDs surveyed also were generally supportive of the dissertation requirement as practiced.

Since our sample is dominated by academics, it is not surprising that the traditional training and dissertation experience has proved to be valuable in preparing them for their careers. They are carrying the torch to the next generation, preparing its bioscientists for a role in academia. Unfortunately, academia will not be in a position to absorb all the new PhDs. If the students have to diversify and move into other industries, it is not certain that the traditional training will serve them as well.

However, the limited data we have in this study on non-research oriented bioscientists indicate that they also were satisfied with their doctoral training. In the other fields, non-academics and non-researchers were also generally not anxious to change the dissertation process. One might wonder whether the perceived worth of the traditional PhD training for non-research-oriented professional pursuits would stand up to objective study. The face validity of that association is not strong (e.g., training teachers by emphasizing research), but we lack hard, comparative data on how well alternative training approaches perform.

From the perspective of the PhDs in our sample, the dissertation experience was a valuable one. It is viewed as an important learning experience, more than a source of scientific advancement; yet, worthy articles do get published from the dissertation. This is consistent with Shull's (1978) perception of what is valuable about the PhD. He argues that doctoral training produces "problem solvers" by "ensuring that each individual possesses a background and a set of tools that enables him or her to define, to attack, and to solve new problems." Shull argues further that part of the solution to the PhD glut is to make employers aware of the value of the PhD outside of academia:

> The fact that we educate problem-solvers is not widely appreciated. Society needs problem-solvers more than ever before, but there is often no recognition that our output of PhDs is a source of prospective candidates for positions that require this attribute.

The dissertation experience clearly embodied more than the completion of a piece of scientific research. It is part of the overall training and socializing process which produces a competent professional. For most individuals who went through a traditional doctoral training program, it is difficult to imagine alternatives to these methods of training.

Footnotes

1. Actually, 171 questionnaires were mailed to zoologists but 2 were misidentified (not 1969-70 zoologists), 1 was out of the country, and 13 were returned as undeliverable; 172 questionnaires were mailed to biochemists but 3 were mis-identified, 1 was out of the country, and 12 were undeliverable.

2. National Research Council data (Summary Report 1970; Doctorate Recipients from United States Universities, Washington, D.C., National Academy of Sciences, OSP-MS-4, 1971; also summary Report 1969, OSP-MS-3, 1970; and other NRC sources) show 15.8% female for calendar year 1969, but that was down to 9.1% for 1970. Our random sample was low in women and we had more difficulty finding addresses for women; then responses were somewhat lower from women (4.8% of those mailed), to yield a response from 2.4% women. The biochemistry sample contains 16.8% women, in line with the population estimate of 15.0%. The only difference between respondents and non-respondents was a slight overrepresentation of those actively publishing (mean initial count of publications by all respondents 6.46 vs. 5.96 for non-respondents and 4.81 for those not addressed).

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Table 1. Features of the Doctoral Training Process

Variable	Zoologists	Biochemists	Six Fields Combined
Aim in Seeking a PhD:			
Research Career	3.8	4.3	3.7
Teaching Career	4.2	3.4	3.6
Factors in Selecting a Particular PhD Program:			
General Reputation of University	3.4	3.5	3.5
General Reputation of the Department	3.6	3.5	3.6
Strength in Specialty Area	3.9	3.2	3.4
Intent of Doing Dissertation with a Certain Faculty Member	3.7	2.8	2.8
Availability of Financial Support	3.4	3.8	3.5
Situational Factors	2.9	3.1	3.3
Rated Quality of Graduate Faculty[a]:			
Strong to Distinguished	9.8%	9.2%	11.5%
Good to Strong	37.4%	36.1%	34.7%
Adequate to Good	38.2%	26.9%	32.6%
Less than Adequate or Unranked	14.6%	27.7%	21.2%
Adequacy of Research Facilities for Dissertation Work (and of 1979 Facilities)	4.1 (3.4)	4.3 (4.2)	4.1 (3.6)
Median Full-Time Equivalent Months on:			
Doctoral Program	42.2	48.2	44.9
Dissertation	20.1	23.8	14.7
Federal Aid Instrumental:			
Fellowship	56.1%	73.1%	53.7%
Research Grant Support	65.0%	89.1%	61.6%
Factors in Choosing a Dissertation Topic:			
Scientifically Important Topic	3.6	3.4	3.4
Personal Interest in Topic	4.1	3.4	3.7
Manageable Study	2.9	2.7	3.1
Faculty Preference	2.9	3.8	3.2
Environmental Considerations	3.0	3.1	2.9
Dissertation Supervisor's Attributes:			
Eminence (1 = not prominent to 4 = top 5% nationally)	2.9	2.6	2.7
Other Dissertations Guided to Completion - mean (median)	13.0 (8.0)	9.0 (3.9)	12.5 (6.2)
Degree Inspired by Supervisor	3.9	3.7	3.7
Co-authored Publication(s) with Supervisor	45.5%	91.4%	56.6%
Evaluation Criteria Imposed on One's Own Dissertation:			
Originality	4.0	3.8	3.7
Scientific Significance	3.8	3.6	3.5
Positive (Confirmatory) Findings	3.4	3.7	3.2

Note: Scaled items, not otherwise noted, reflect means on 5-point scales anchored at 1 = not important and 5 = very important.

[a]Charles J. Andersen of the American Council on Education kindly provided explicit scale scores from A Rating of Graduate Programs by K. D. Roose and C. J. Andersen (Washington, D.C., 1970). These peer ratings coincide with our cohort's graduate training. The scale is 5 = distinguished, 4 = strong, 3 = good, 2 = adequate, 1 = marginal.

Table 2. Early Career Features

Variable	Zoologists	Biochemists	Six Fields Combined
Dissertation Research:			
Carried Forward After Receipt of Doctorate	2.8	2.0	2.4
Relevance to Initial Post-PhD Work (and to 1979 work)	3.4 (3.2)	3.1 (2.7)	3.0 (2.6)
Employment:			
Post-doctoral Work Done	41.5%	72.9%	35.9%
Mean Percent of Full-Time Equivalent Employment Since PhD in Academic Institutions	86.9%	65.4%	62.6%
Primary Work Activity on First Post-PhD Job (and on 1979 job):			
Research	35.2% (12.4%)	87.3% (44.3%)	38.1% (19.1%)
Research and Teaching	16.4% (41.3%)	3.4% (22.6)	11.3% (19.5%)
Teaching	45.1% (29.8%)	3.4% (4.3%)	29.2% (19.3%)
Administration-Related	0.8% (11.5%)	0% (9.6%)	1.6% (17.9%)
Median Salary on 1979 Job:	22,500	26,000	27,000
(25th and 75th percentiles)	(19,500-27,000)	(22,000-32,500)	(22,000-34,500)

Note: Scaled items reflect means on 5-point scales anchored at 1 = not important to 5 = very important.

Table 3. Perceptions of Dissertation Experiences and of Potential Changes

Variable	Zoologists	Biochemists	Six Fields Combined
<u>Views on One's Own Dissertation:</u>			
Satisfied with Choice of Dissertation Topic	4.1	3.5	3.7
Yielding Valuable Research Findings	3.6	3.3	3.3
Learning To Do Independent Research	4.5	4.4	4.3
Learning Work-related Research Skills	3.8	4.1	3.8
Learning to Write for Scholarly Publications	4.0	3.6	3.7
Learning Non-research Professional Skills	3.6	3.3	3.3
Generally a Valuable Experience	4.5	4.2	4.1
<u>Evaluation of 1979 Dissertation Practices:</u>			
Emphasis on Originality	2.9	2.6	2.7
Emphasis on Positive Research Results	3.3	3.2	3.4
Emphasis on Relevance of Dissertation to Students; Career Needs	2.7	2.6	2.5
<u>Perceptions on Desirability of Possible Changes:</u>			
Increase in Standards and Requirements for Obtaining the PhD	3.2	3.5	3.1
Replace Dissertation with Several Original Research Exercises	2.1	2.0	2.2
Continue Dissertation Research but Write Up in Several Short Reports like Articles for a Journal	2.9	2.8	2.7
Substitute Dissertation with Activities Designed to Acquire Non-research-oriented Professional Skills	1.9	2.0	2.1
Alternative Doctoral Degrees Not Oriented toward Research	2.3	2.3	2.6

<u>Note</u>: All items reflect means on 5-point scales. Views on One's Own Dissertation range from 1 = not satisfactory to 5 = very satisfactory; Evaluation of 1979 Dissertation Practices, from 1 = too little emphasis to 5 = too much emphasis; Perceptions on Changes, from 1 = strongly disapprove to 5 = strongly approve.

APPENDIX G

DOCTORAL TRAINING AND EARLY CAREER PATTERNS IN SOCIOLOGY: AN ASSESSMENT OF/BY THE 1969-70 COHORT*

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Abstract

The role of graduate training and, especially, the dissertation, is evaluated in light of the first post-doctoral decade for a cohort of sociologists awarded the Ph.D. in 1969-70. Sociologists progress relatively rapidly through the process, devoting an average of one full-time-equivalent year to the dissertation. They evaluate the dissertation experience as highly satisfactory on several dimensions. In terms of research, somewhat more than one open literature publication can be traced to the dissertation study. The dissertation-related publications generate more citations per year than the other published work by the respondents, an endorsement of the utility of dissertation research. None of a series of potential changes in doctoral requirements receive endorsement by these Ph.D.s. While this cohort has pursued predominately academic careers, implications of graduate training for a less academic job market are explored.

DOCTORAL TRAINING AND

EARLY CAREER PATTERNS IN SOCIOLOGY:

AN ASSESSMENT OF/BY THE 1969-70 COHORT

Introduction

A multitude of articles have appeared in ASA Footnotes, The American Sociologist, and other professional journals about the dwindling academic job market for Ph.D.s in sociology. Such warnings can be found in the sociological literature of the early 1970's (Finsterbusch, 1972; Janowitz, 1972; McGinnis and Solomon, 1973). More recent articles re-emphasize the need for diversification and exploration of non-academic jobs. Indeed, a major theme of Peter Rossi's (1980) presidential address to the American Sociological Association in 1980 was the need for sociologists to develop a more favorable attitude toward applied social research and to train cohorts who can successfully compete for research jobs in the expanding non-academic sector. As Rossi (1980:903) points out, sociology is primarily an academic discipline with far fewer sociologists employed outside academe than in other social sciences such as economics or psychology. Others (Tuchfeld, 1976; Morrissey and Steadman, 1977; Kay, 1978) have challenged this view, however, as unfounded optimism, and raised new questions about current practices in the doctoral programs training Ph.D.s in sociology, how they affect the later careers of sociologists, and whether they can generate individuals capable of competing in a diminishing job market. While there are departments that offer concentrations in applied sociology (van de Vall and Bolas, 1980), most sociology departments with doctoral programs still are biased toward training students for scholarly research and teaching, not an "applied" career.

Without discussing either the current market quandry for new Ph.D.s or doctoral training orientations within sociology, we use this contemporary backdrop to examine the experiences of a cohort of Ph.D.s who first faced the job market of the 1970's. Using a data set containing information on the doctoral training process, the post-doctoral career, and attitudes toward the graduate training experience, we can evaluate the role of graduate training on the early post-doctoral career, as subjectively reported by respondents. Given that the academic job market has deteriorated throughout the 1970's, we realize that the aggregate experience of our study cohort cannot be generalized to subsequent cohorts of Ph.D.s in sociology. However, new Ph.D.s do not have the benefit of a sufficient number of years in the job market as a basis for reflecting on the utility of graduate training in general, and the writing of the dissertation as a preparation for a career in science. Because our respondents shared their perspectives on job expectations, constraints, and performance, we are afforded an unusual opportunity to reconstruct early career patterns of American sociologists that are relevant to the employment myths, ideologies, and practices currently under debate.

Study Design

In our study, the role of graduate training and the dissertation experience are evaluated in terms of the first post-doctoral decade of career experiences for a cohort of sociologists awarded the Ph.D. in 1969-70. A random sample of sociologists listed in Dissertation Abstracts in 1970 was sent a six-page questionnaire focusing on their graduate training and later careers. Follow-up letters and phone calls resulted in 93 usable questionnaires (a response rate of 66% based on a deliverable sample of 142 that excludes misidentified individuals and undeliverables). Although only the data on sociologists will be presented here, comparable data for a sample of doctoral recipients in five other disciplines--biochemistry, electrical engineering, physics, psycology, and zoology--were collected for a larger, cross-disciplinary study of the role of the doctoral dissertation in career productivity and will be alluded to occasionally (Porter et al., 1981). Comparison of our sample's characteristics with population profiles derived from the National Research Council's Doctorate Records File and the Office of Education's Earned Degrees Conferred shows excellent correspondence.

Our findings are organized under the following topics: 1) characteristics of the sample; 2) graduate training and dissertation experience; 3) evaluation of the dissertation experience, including an evaluation of current practices; 4) work history of the sample; and 5) recommendations for change in graduate training. Thus, the findings, while descriptive and retrospective, are nonetheless offered as prescriptive of future policy.

Findings

1. Sample Characteristics. Of the 93 sociologists in our sample only 17 or 18.3% were female; this is identical to the population percent of female sociologists receiving the Ph.D. in 1969-70. The mean age of the sample upon completion of the doctoral work was 35, and over 80 percent of the sample was married. The average number of dependents in the year prior to the Ph.D. was 2 and female doctoral candidates had fewer dependents than their male counterparts. Fifty-five percent of the sample reported that a fellowship, research, or teaching assistantship was the primary source of support during the research stage of the dissertation; full-time employment was the primary source for 25%. During the writing stage of the dissertation, 43% had fellowships or research

and teaching assistantships, while 35% of the sample depended on full-time employment as their primary means of financial support. In sum, fully a third of these sociologists were working full time while striving to complete the dissertation. It comes as no surprise that fewer sociologists than members of the other five disciplines studied found Federal grant or fellowship support instrumental to their work since only 27% of the sociologists compared with 68% of the others had grants and 33% of the sociologists compared with 58% of the others had fellowships/traineeships.

2. Graduate Training and the Dissertation Experience. Respondents were asked to rate the importance of a variety of factors in their decision to select a particular doctoral program. The results of this evaluation are presented in Table 1. All but one of the factors were

(Insert Table 1 about here)

considered important in the selection process. Intention to do the dissertation with a particular faculty member was not as important a factor as the general reputation of the department, followed in order by situational factors (such as geographic location, familiarity with the department, and spouse's career opportunities), the general reputation of the university, the department's strength in a specialty area and availability of financial support. It is notable that the importance of situational factors in choice of a graduate program was the strongest correlate of sex (r=.29) of the hundred-odd variables derived from the survey, with women more apt to be affected by situational considerations. From Table 1, it would appear that the selection of a particular Ph.D.

program in sociology is based on a combination of factors with situational factors playing about as important a role as more professional considerations such as the reputation of the university.

a. Career Aims. Respondents were asked to rate the importance of various career aims in their decision to seek a Ph.D. (Table 2). The

(Insert Table 2 about here)

teaching career was far and away the most important career aim and was rated as important or very important by 76% of the respondents in our sample who answered the question. A research-oriented career was a distant second with 41% of the respondents to the item evaluating it as important or very important. (Although 43% of the respondents to the "Other" category indicated that some other aim was important or very important, there were only 30 responses to this item in all.)

b. Choice of Dissertation Topic. Respondents were asked to evaluate the importance of a variety of factors in their choice of dissertation topic; three were rated as important (Table 3). That the topic be

(Insert Table 3 about here)

personally meaningful to the student was seen as the most important consideration in the choice of a dissertation topic. That it be a scientifically important topic to which the student can make a real contribution was the second most important factor. Third was that the topic be a manageable one. These results suggest that the student had a great deal of autonomy in the choice of dissertation topic and that he or she was influenced by the criterion of scientific relevance. At the same time, the student was concerned that the project be "doable." However, faculty preference was a determining factor for some students. As one put it (44% of the respondents elaborated on some of the questions with written notes), "The topic . . . was chosen programmatically, under the guidance and pressure of my advisor."

c. Time. The median time spent by our cohort of sociologists as doctoral students was 39.7 months--less than for all our other fields except electrical engineering (the six-field median was 44.9 months). Most of the respondents began work on the dissertation late in their program: 27% during later coursework, 10% after courses, and 42% after their candidacy. A majority of the sample felt that the dissertation should have been started earlier. The median full time equivalent months taken to complete the dissertation was 12.3 (mean = 15.7) months compared to a six-field median of 14.7 months. A majority of the respondents thought that the amount of time spent on the dissertation was about right (64%); 20% thought it too long and 5% too short.

The respondent's allocation and evaluation of the time to various stages of the dissertation research are presented in Table 4. Data gathering is the activity reported to take the greatest amount of time. Combined with data analysis it occupied almost 50% of the total time spent on the dissertation. The actual writing of the dissertation was a close second to data gathering for amount of time spent. Respondent's ideal allocation of time to the various activities is remarkably similar to the actual allocation (Table 4). The biggest discrepancy is in the

(Insert Table 4 about here)

amount of time allocated to data gathering. The ideal allocation is 4% less than the actual time spent.

d. Role of the Dissertation Supervisor in the Dissertation. A series of questions was asked regarding the role of the dissertation supervisor in the graduate training process. Sixty-one percent of the sociologists reported moderate to heavy supervision throughout their work on the dissertation. The median number of other dissertations being supervised at the same time by the dissertation supervisor was reported to be 3 (mean = 5 ± 10). Respondents estimated that their supervisors had guided a median of 10 (mean = 16.5) dissertations to completion previously. This suggests a dramatic clustering of Ph.D. students around relatively few faculty members. Almost 63% of the sociologists reported being stimulated by their supervisor. About 26% of the sample co-authored at least one publication with their supervisor (far less than in any other field; the other five fields average 62%). Twenty-two percent indicated that they would have carried the dissertation work forward if they had some financial support, such as a post-doctoral fellowship.

A sampling of comments provides more flavor of the range of possible advisor-student relationships that are so central to the graduate training experience:

> He provided invaluable insight and judgment . . . and he always dealt with me in a fair and adult way that never demeaned me or my efforts. He was very supportive as a human being and near colleague.

> He provided quality standards that I still use today (as do many of his other students). He insisted upon excellence, regardless of costs.

> He [my advisor] had the wisdom to leave me alone and let me make my own mistakes, but gave me guidance when asked to.
>
> I usually had to make . . . and then cancel 5-6, even 7-8 appointments before I got to talk to my chair. When I saw him, he was helpful.
>
> My dissertation experience was one where I put all the pieces together with little or no aid.

3. Evaluation of the Dissertation Experience. Table 5 presents the responses to a series of items asking respondents to evaluate their dissertation experience on a number of factors traditionally associated

(Insert Table 5 about here)

with the writing of a dissertation. All aspects of the experience turned out to be satisfactory. Respondents reported--with strong consensus--that the experience in general was valuable. The most specifically satisfying aspect of the experience was learning to do research independently. On another item respondents were asked whether they were satisfied with their choice of dissertation topic and the majority reported that they were. A few comments, however, highlight the fact that the dissertation experience was not "universally positive":

> Despite the dangers of exploitation of students and triviality of dissertation research, I am inclined--regretfully--to believe that the most efficient training for research can be gained in apprentice-like situations in large academic research organizations.
>
> More emphasis should be placed on teaching skills, human and humane ways of interacting with students.
>
> What I thought was important then does not seem so now.

From a research perspective, one can assess the dissertation in terms of its contribution to the scientific literature. In these terms, 27.3% of the cohort published one or more articles, books, book chapters, or conference proceedings papers based directly on the dissertation, for a mean of 0.58 per person. Moreover, 28.6% published research reflecting continuation of the dissertation work for a mean of another 0.73 publications. So, on average, somewhat more than one publication per person out of a mean "first decade" total of 7.18 (median 4.25, with 63.4% publishing at least once) traced its roots directly to the dissertation. Interestingly, the papers derived from the dissertation generated more citations per paper than other publications: 3.04 citations/paper (57.8% of the papers cited at least once) for those directly from the dissertation, and 1.93 (41.1% cited) for those from continuation of the dissertation research, versus 1.43 for earlier work (37.1% cited) and 0.79 for later work (29.9% cited). One can correct for the number of years since publication during which citations could accrue by computing citations/publication/year (as tabulated from the Social Science Citation Index and Science Citation Index for 1970 through 1978) and take the logarithm to reduce the weight placed on heavily cited papers. This measure still shows sociologists (and all six fields combined) receiving more recognition for the papers derived from their dissertations than from later work not related to the dissertation. This is an endorsement of the utility of published dissertation research, but it must be remembered that only a minority of dissertations so reach the open literature (see Yoels, 1973).

In terms of current dissertation practices in sociology (Table 6), respondents felt there was somewhat too much emphasis placed on positive research results and not quite enough on originality or the relevance of the dissertation to later career needs of the candidates.

(Insert Table 6 about here)

4. Work History. The post-doctoral work history of our sample is summarized in Table 7. It is clear that they are thoroughly entrenched in academe.

(Insert Table 7 about here)

During approximately 10 years of employment, an average of 8.6 years was spent in the academic sector. Thus, it is not surprising that the major work-related activities were teaching and research (Table 8). Over 80%

(Insert Table 8 about here)

of the sample was involved in teaching on the first job and over 50% on the current job. About 25% of the respondents were involved in research on the first job with almost equivalent involvement on the current job. If teaching and research are taken together, they account for 89% of the primary work activities on the first post-doctoral job and 61% on the current job. A major reported difference between activities on the first post-doctoral job and the current job is the importance of teaching. Almost 64% reported that teaching per se was their primary work activity on their first job, versus 37% so reporting for the current job.

A second distinction between the first and the current job is the involvement in administrative activities. On the first job only 5% reported administration (alone or in combination with research or teaching) as a primary work activity compared with 29% on the current job. Since time spent on other activities remained relatively constant, the shift seems to be from exclusively teaching to administration and, in some cases, administration combined with some other activity.

5. Evaluation of Proposed Changes. As a prelude to recommending changes in doctoral requirements, respondents were asked to evaluate the relevance of their dissertation to their primary work activity both for their current job and their first post-doctoral job. The results of their evaluation are presented in Table 9. Surprisingly, the dissertation

(Insert Table 9 about here)

was about as relevant to the work activities on the first as on the current job: 34% indicated that it was relevant to the first job compared to 33% reporting relevance on the current job. At the other extreme, 38% found the dissertation not relevant to the first job whereas 47% found it not relevant to the current job. On average, the dissertation was evaluated as not highly relevant either to the first job or to the current job. Not surprisingly, those engaged in research during those periods reported the dissertation as more relevant than those not so involved. Interestingly, the rating of the dissertation as a valuable experience held up well across all categories of current work activity, approximately "4" on the 1-5 scale for all categories.

When asked to rate a series of proposed changes in doctoral requirements, e.g., substituting other work for the dissertation, the respondents endorsed none that appeared on the questionnaire and suggested no alternatives. The results of this evaluation appear in Table 10.

(Insert Table 10 about here)

Discussion

By all measures, our sample appears to be quite satisfied with the graduate training received and the dissertation experience, showing mild disapproval for proposed changes in the traditional requirements. The general impression emerging from these data is that the dissertation admirably serves its educational and training function. The respondents felt that the dissertation experience had taught them how to do independent research. In addition, the dissertation was relevant to about a third of the sample on the first post-doctoral and on the current job.

Since our sample represents, temporally at least, a distinctive set of aggregate experiences, and perhaps an "old" academic orientation among sociologists, it is not possible to derive from it recommendations for changes geared toward a non-academic orientation. However, it does not appear as if the cohort represented by this sample experienced significant problems in the labor market; therefore, its members would tend to think their training was appropriate for the jobs they ultimately obtained. No doubt there is a dose of self-fulfilling prophecy to such post hoc judgments. If we repeated this study for a cohort of Ph.D.s receiving their degrees 5 years later, for example, might we find a higher degree of dissatisfaction with graduate training, as judged in the light of early career patterns that fall short of the sociologists' own expectations? It is conceivable that most people know what they are getting into when they enter doctoral training. Perhaps through a self-selection process, individuals unwilling to risk failure to secure a job in academe decide against graduate training in sociology.

Uncertainty about the viability of careers may be translated earlier into decisions not to pursue degrees in certain fields, especially the social sciences and humanities. Such voluntary "birth control," accomplished by attrition at all degree levels, may ease the market pressures that newer sociology cohorts face. Since cross-disciplinary information on the rates and reasons for attrition are still largely lacking (see Horowitz, 196 ; Jacks et al., 1981), we have no way to gauge the typicality of sociology's--and sociologists'--plight. Abortive attempts to launch a career in sociology are as essential for explaining the choices of work sector and activities as are analyses like the present one focused solely on Ph.D. recipients. What becomes of the M.A. and A.B.D.? What is the market significance of such "partially-trained" sociologists? Do they represent competition to Ph.D.s who are viewed as embodying a narrow range of skills applicable to only a single professional role, audience or employer? Finally, are the successful 1969-70 cohort members foreclosing opportunities for the 1979-80 sociology cohort? Are their destinies somehow intertwined?

Conclusions

We began by proposing the current paucity of academic jobs for sociologists as a backdrop for viewing the early career experiences of a decade-old cohort. With our analysis in mind, we can now address the issue anew.

For sociology to become a more applied field, some of its degree-granting departments would have to shirk the disciplinary bias against applied work assailed by Rossi. No doubt some departments have. More likely, however, there has been resistance to offering training oriented toward an applied research career. This is because department orientations, steeped in tradition, die hard. Faculty refuse to bow to market pressure, to modify curricula so as to attract students who enter the field with non-academic employment in mind. There are several competing issues here: the obsolescence of training, the preservation of disciplinary purity, a pandering to fads and transitory conditions, a re-assertion of sociology's mission(s) or purpose, the inability or unwillingness of a faculty to reorient in the face of new societal and student needs. None of these issues is new. Yet responses to them must be novel if sociology is to avert a training crisis that affects its practitioners through a loss of student clientele (see TAS, 1980).

A descriptive analysis of the 1969-70 Ph.D. cohort in sociology can provide no novel responses. But it does foreshadow change: just as this cohort is satisfied with its graduate training experience, within the first decade of their careers work activities have been transformed. From research on earlier cohorts (Crowley and Chubin, 1976), we know that immobility between employment sectors is a concomitant of sociologists' career development. Together with other indicators of job performance, e.g., salary (see Lewis et al., 1979; Chubin et al., 1981), we can predict an uncertain, unstable future for later sociology cohorts. Indeed, the continuing redefinition of careers in sociology to include, as legitimate and desirable, applied nonacademic work may be the only means of reducing uncertainty and restoring stability. Rossi, in short, may be right--but not right for the entire discipline.

TABLE 1

IMPORTANCE OF FACTORS IN SELECTING A PARTICULAR Ph.D. PROGRAM

Factor:	Mean Importance Rating (1=not important; 5=very important)
General Reputation of University	3.4
General Reputation of the Department	3.6
Strength in Specialty Area	3.3
Intent of doing dissertation with a Particular Faculty Member	2.4
Availability of Financial Support	3.1
Situational Factors	3.5

TABLE 2

IMPORTANCE OF CAREER AIMS IN SEEKING A Ph.D.

	RATING (1=not important; 5=very important)							
CAREER AIM:	N/A	1	2	3	4	5	Mean	N
Research Career	-	11%	27%	21%	18%	23%	3.1	84
Teaching Career	-	2%	4%	17%	18%	58%	4.2	89
Professional Practice	-	41%	19%	14%	9%	17%	2.4	78
Other	40%	17%	-	-	10%	33%	.5	30

TABLE 3

IMPORTANCE OF FACTORS AFFECTING CHOICE OF DISSERTATION TOPIC

Factor:	EVALUATION (1=not important; 5= very important)
Scientifically Important Topic	3.3
Personal Interest in Topic	3.8
Manageable Study	3.2
Faculty Preference	2.9
Environmental Considerations	2.6

TABLE 4

ALLOCATION OF TIME TO VARIOUS PHASES OF THE DISSERTATION

	AMOUNT OF TIME ALLOCATED	
DISSERTATION PHASE:	Actual	Ideal
Problem Formulation	19.7%	21.3%
Equipment Preparation	4.6%	5.6%
Data Gathering	27.4%	23.1%
Data Analysis	21.4%	23.0%
Writing	25.5%	24.0%
Other	2.5%	0.5%

NOTE: Percentages do not sum to 100 because the number of respondents varied from item to item; values shown are the mean responses for each item individually.

TABLE 5

EVALUATION OF DISSERTATION EXPERIENCES

Aspect Evaluated:	Mean Rating (1=not satisfactory; 5=very satisfactory)
Yielding valuable research findings	3.4
Learning to do independent research	4.2
Learning to write for scholarly publications	3.6
Learning non-research professional skills	3.4
Generally a valuable experience	4.1
Satisfied with choice of dissertation topic	3.8
Learning work related research skills	3.7

TABLE 6

EVALUATION OF CURRENT DISSERTATION PRACTICES

Practice Evaluated:	Evaluation (1=too little emphasis; 5=too much emphasis)
Emphasis on originality	2.4
Emphasis on positive research results	3.6
Emphasis on relevance of dissertation to student's career needs	2.5

TABLE 7

EMPLOYMENT SINCE EARNING THE DOCTORATE

Type of Employer:	0	Full Time Years of Employment 1-2	3-5	6-9	10+	Mean
Business or Industry	90.2%	8.6%	–	–	1.1%	0.2
Academic Institution	5.4%	2.2%	3.3%	40.2%	48.5%	8.6
Government	8.7 %	8.6%	2.2%	2.2%	–	0.4
Other	89.1%	2.2%	4.4%	4.4%	–	0.5

TABLE 8

PRIMARY WORK ACTIVITY

Activity:	First Post Ph.D. Job	Current Job
Research	7.7%	8.9%
Research and Teaching	17.6%	15.6%
Teaching	63.7%	36.7%
Development Design	1.1%	1.1%
Professional Service	3.3%	2.2%
Administration	2.2%	16.7%
Administration and Research or Teaching	3.3%	12.2%
Other	1.1%	5.6%

TABLE 9

RELEVANCE OF DISSERTATION TO WORK ACTIVITY

	Score (1=not very relevant; 5=very relevant)					
Job status:	1	2	3	4	5	Mean
First Job	14.3%	24.2%	27.5%	22.0%	12.1%	2.9
Current Job	16.5%	30.6%	20.0%	18.8%	14.1%	2.8

TABLE 10

EVALUATION OF CHANGES IN DOCTORAL REQUIREMENTS

Proposed Change:	Mean Evaluation (1=strongly disapprove; 5=strongly approve)
Increase in standards and requirements for obtaining the Ph.D.	3.0
Replace dissertation with several original research exercises	2.1
Continue dissertation research but write up in several short reports like articles for a journal	2.5
Substitute dissertation with activities designed to acquire non-research oriented professional skills	2.2
Optional alternative non-research oriented degrees	2.7

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CAREER PATTERNS OF SCIENTISTS: A CASE FOR COMPLEMENTARY DATA*

(COMMENT ON LONG ET AL., *ASR*, OCTOBER 1979)

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Introduction

Fascination with "status attainment" as a fundamental dimension of social structure and institutional stratification now pervades the sociology of science (Hargens, 1978:123–236). A corresponding dependence on unobtrusive data sources has been made possible by such inventions as the *Science Citation Index*, biographical compendia such as *American Men and Women of Science*, and graduate program ratings compiled by the American Council on Education. While we, too, have utilized these sources for reconstructing scientists' career patterns (Chubin, 1974; Crowley and Chubin, 1976; Porter and Wolfle, 1975; Porter, 1977), our fascination differs from the genre of analysis reported in this journal.

For example, two recent studies of careers of biochemists (Long, 1978; Long et al., 1979) focused exclusively with unobtrusive data on prestige or status attainment and ignored other dimensions that the literature on career patterns of scientists has illuminated. In response, this comment seeks to clarify the limits of gen-

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eralizing the results from the study of Ph.D.s in one scientific field to other fields (which Long et al., 1979:829, deem unproblematic), and to augment the analyses of 1957–1958 and 1962–1963 Ph.D. cohorts in biochemistry with a comparative analysis of 1969–1970 Ph.D.s in six fields, including biochemistry. Through the latter, we intend to show that scientists' self-reports complement findings based solely on public-domain data. Without "subjective" data, we argue, the mechanisms that underlie career decisions and generate observed patterns of employment, productivity, and prestige remain obscure.

Complementary Data

Our data base consists of 645 responses to a six-page questionnaire mailed February 1979 to a random sample of 1969–1970 Ph.D. recipients from U.S. universities. The sample was stratified by field with an overall response rate of 70% (see Appendix). Among the areas we surveyed are the following: the role of the student's dissertation supervisor or mentor (including coauthorship with him/her prior to the student's first post-Ph.D. job), the full-time equivalent (FTE) years employed in business/industry, government, and academe; and the extent to which research has been the primary work activity.

These data are retrospective accounts of career experiences over a ten-year period and are subject to scientists' rhetoric—the omissions, juxtapositions, and embellishments of their recollections (Mulkay, 1974, 1976; Woolgar, 1976; Studer and Chubin, 1980). We are not claiming the infallibility of scientists' accounts, but only that recollections elicited in response to closed- and open-ended questions about a memorable time in the scientist's professional life can augment information gathered from archival sources. The survey data we have gathered can provide insights into processes, motives, and intentions—the behaviors which all-too-routinely are attributed to scientists in the absence of direct measurement.

Beyond Prestige: Sectors of Employment. Table 1 summarizes the cross-field comparisons on seven key variables for our 1969–1970 Ph.D. sample. Among other findings, it shows great variation by field in the extent of academic employment among the cohort. Specifically, a substantial portion of the biochemists' first post-Ph.D. decade was spent in nonacademic settings. Long (1978:892) notes the atypicality of productivity patterns among biochemists who leave academe (examined below), yet is willing to generalize from academic biochemists to all scientists.

The primary work activities of our sample vary strikingly across fields, with biochemistry an extreme. That is, research appears to be more prominent for biochemists; hence, it might be expected to relate more strongly to their professional attainment than would be the case for other scientists. A general reduction in research and teaching with a commensurate increase in administration is also evident over the decade, but biochemistry is still the extreme.

As Zuckerman and Merton (1972) suggest, transitions out of research activity adversely affect productivity. Too often, however, productivity studies such as Long et al.'s (1979) tend to link positional status with publication productivity alone, thereby neglecting other "local" factors that possibly contribute to prestige, such as teaching and administration (see Whitley, 1977). Instead of assuming that moribund research "pushes" scientists out of that activity, we must consider the "pull" of other activities and roles which themselves command prestige or its surrogates, such as high remuneration. This may especially be the case in nonacademic sectors of employment (Marsh and Stafford, 1967) where appropriate performance measures are lacking (Reskin, 1979:144).

Reinterpreting the Postdoctoral Appointment. Certainly a factor in any "prestige tradeoff" would be the market conditions faced by the new Ph.D. For example, we would expect differences in the early careers of a cohort of scientists trained prior to Sputnik and of one awarded the Ph.D. thereafter. Long et al.'s (1979) two cohorts straddle this particular reality—a "social shock" that reshaped the employment market for Ph.D. scientists throughout the 1960s—yet they are aggregated for analysis. The 1969–1970 cohort confronted a different reality when embarking on their careers: the beginnings of a shrinking, inflation-wracked economy.

We not only asked our sample whether a postdoctoral position was obtained, but also inquired as to the reason for taking it. As inferred from Table 1, the glut of Ph.D.s produced since Sputnik had begun to take its toll on the job market, particularly on physicists. Part of the strategy in coping with such a market—actually comprised of national, regional, and special-interest submarkets (Hargens, 1969; Brown, 1967)—is the acquisition of new skills to enhance one's employability, i.e., to extend one's capabilities beyond those certified by receipt of the doctorate. Market conditions, or perceptions thereof, can affect decisions that alter the course of a career. These same conditions un-

Table 1. Selected Cross-Field Comparisons Among 1969–1970 PhDs

Variable	Biochemistry	Electrical Engineering	Physics	Psychology	Sociology	Zoology	All
Total N	119	106	97	107	93	123	645
Academic Employment:							
%[a] reporting ≥ 50% FTE years academic[b] (mean FTE years academic)	65.5 (5.7)	29.5 (2.6)	50.5 (4.9)	57.5 (5.3)	89.2 (8.6)	90.2 (8.2)	64.3 (5.9)
Primary Work Activity: First Post-Ph.D. Job (Current Job)[c], in %[a]							
–Research, or research and teaching	90.7 (67.0)	36.5 (26.4)	54.3 (34.7)	29.9 (18.1)	25.3 (24.4)	51.6 (53.7)	49.4 (38.6)
–Teaching	3.4 (4.3)	13.5 (4.7)	27.7 (22.1)	27.1 (21.0)	63.7 (36.7)	45.1 (29.8)	29.2 (19.3)
–Administration, or administration and research or teaching	0.0 (9.6)	1.9 (25.5)	0.0 (14.7)	1.9 (20.0)	5.5 (28.9)	0.8 (11.6)	1.6 (17.9)
Postdoctoral Positions Held, in %[a]	72.3[d]	9.5	40.2	26.2	18.5	41.5	35.9
Reasons Given for Taking Postdoctoral Positions, in %[e]							
–Research experience	70.6	30.0	53.8	46.4	53.3	83.3	64.4
–Switching specialty area	14.1	10.0	2.6	28.6	33.3	8.3	13.8
–Lack of desirable permanent employment	11.8	30.0	43.6	0.0	0.0	6.3	14.7
Coauthored a Publication with Dissertation Supervisor, in %[a]	91.4	62.7	65.3	44.3	26.1	45.5	56.6
Early Career Publication[f]:							
% with no journal articles	7.6	35.8	14.4	34.6	36.6	17.9	23.9
% with 10+ journal articles	49.6	12.3	28.9	23.4	21.5	36.6	27.6
Mean (Median) articles	11.1 (9.4)	4.6 (2.1)	7.6 (4.6)	5.4 (2.4)	5.3 (3.2)	9.0 (6.6)	7.3 (4.5)
Received Important Assistance from Their Supervisor in Obtaining First Post-Ph.D. Job, in %[a,g]	37.2	15.8	31.2	20.2	22.2	26.5	25.9

[a] Percentages are based on number responding unambiguously (i.e., blanks and special situations excluded).

[b] Full-time equivalent years spent employed in academic institutions divided by the sum of FTE years academic, industry, government, and other.

[c] Two categories are excluded: "professional service" (e.g., 37.4% of the psychologists' first activity) and "development and design" (e.g., 39.6% of the electrical engineers' first dominant activity); hence percentages do not sum to 100.

[d] The great majority of the biochemistry postdoctoral appointments took place immediately after completing the doctorate; this is consistent with Long et al.'s (1979:893) 65% so engaged.

[e] "Other" category not shown; it is the difference from 100%. Note that the Ns are low in some fields (e.g., 10 postdocs in EE in all).

[f] Source: SCI *Source Index* (SSCI as well for sociologists and psychologists) corrected by reports of survey respondents.

[g] Percent noting "very important" or "important" on a 5-point scale.

derscore the social mechanisms, typically conceptualized as particularism vs. universalism, which affect not only entrance to the scientific career but also the configuration of paths taken thereafter.

Particularism vs. Universalism Reconsidered. Figure 1A attempts to simplify the key features of the argument presented by Long et al. Employing a series of regressions based on a longitudinal data base, they conclude that prestige of the first job strongly associated with prestige of the most recent prior departmental affiliation (i.e., postdoctoral appointment or Ph.D. granting institution), moderately associated with mentor's prestige, and negligibly associated with pre-Ph.D. publications. Conversely, they find the best predictor of later career publications to be pre-Ph.D. publications, while Ph.D. rating, postdoc rating, and mentor prominence are unimportant (see Table 2, part A). Long et al. conclude that particularism is at work inasmuch as first academic appointments relate to reputational factors irrelevant to later scientific productivity, but not to pre-Ph.D. publications which do relate to later productivity.

We have selected a set of variables derived from our data base to gauge the comparability between relationships observed for the 1969–1970 cohort and Long et al.'s findings. Figure 1, Part B depicts our model with the relationships observed, while Table 2, Part B, provides the numerical details of those observations. Our measures of Ph.D. rating, early publications, and prior publications are conceptually similar to Long et al.'s, although operationally somewhat different. We consider whether a postdoctoral appointment was taken rather than the rating of its prestige, and we approach mentor prestige quite differently (see notes to Table 2). Lacking prestige ratings in our Ph.D.s' employment settings, we sought an alternative to publication and citation as measures of professional stature. We were directed to salary as the most suitable variable, as based

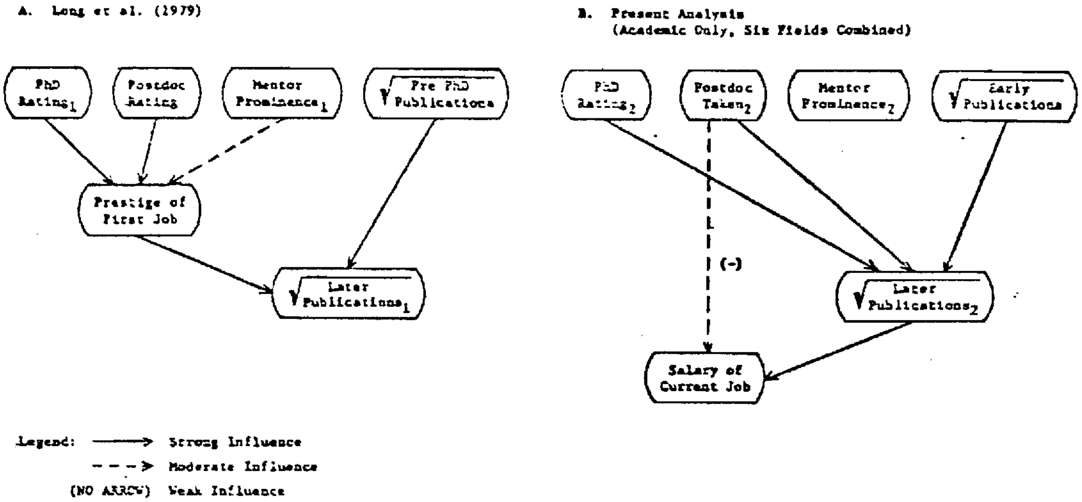

Figure 1. Simplified Models

NOTE: See Table 2 for definitions and details. Variables are not operationally equivalent in the two models. Some variables used in each analysis are omitted from A and B.

on extensive studies by the National Research Council (Harmon, 1963; Harmon, personal communication). Current salary chronologically follows later publications (but multiple panel data to uncouple these measures satisfactorily are not available). This distinguishes our model from Long et al.'s in that prestige of first job antedates later publications. We report regression coefficients predicting later publications among biochemists and for the academic scientists in our five other fields (Table 2). In Table 3, we summarize salary predictions for the two employment sectors (academic vs. nonacademic) in each of the six fields.

We suggest three interesting counterpoints to Long et al. (1) The linkage between mentor stature and first job must be challenged. Their citation-based mentor stature measure potentially confounds work of coauthors with the protege's own. Indeed, Table 1 indicates that over 90% of our biochemists coauthored with their dissertation supervisors (far more than in any of our other five fields);[1] thus, mentor stature has diminished explanatory power vis-à-vis the students' placement. Furthermore, the pre-Ph.D. publication rate may be inherently correlated with mentor stature as measured by Long et al. Our mentor prominence measure is conceptually independent and is virtually uncorrelated with pre-Ph.D. publication rate (r = .08 for all respondents). It does correlate with Ph.D. institution rating (r = .30 for all respondents, but only .14 for academic biochemists).[2]

(2) The moderate linkage between mentor prominence and first job prestige reported by Long et al. deserves reconsideration. As shown in Table 1, only about one in three of our biochemists—and this is a greater proportion than in other fields—perceived that their mentors were important in their securing a first job.[3] Context, too, must be weighed. For in-

[1] Sixty-nine percent of the biochemists related that a key reason for selecting their dissertation topic was its preference by their supervisor. The student's personal interest in the topic, its manageability, and potential intellectual contribution were considerably less influential. A similar pattern obtained only for the physicists; in all the other fields personal interest dominated faculty preference as an influence on topic choice.

[2] Notably, from our cohort's perspective, a key reason for selecting the Ph.D. program in which they were trained was the availability of financial support: over 60% of the biochemists, psychologists and physicists cited this—more than deemed important reputation of the university, department, or specialty; presence of a particular faculty member; or situational factors (responding 4 or 5 on scales from 1 = not important to 5 = very important). For the sociologists and electrical engineers, reputation of the department and the university, respectively, most influenced their choice of graduate program. Only the zoologists reported that the presence of a faculty member most affected their choice. The 63% reporting this as a vital selection criterion contrasted with the 25% of the sociologists, psychologists, and physicists for whom particular faculty were a major influence in their decision to enter a program (multiple choices were permitted).

[3] However, as one anonymous referee suggested, "those who get really good jobs can attribute it to their own talents; those who don't get good jobs can also say their mentors did not help them." Such rationalizations no doubt occur. But the accounts of the Nobel laureates interviewed by Zuckerman

Table 2. Regressions Relating Scientists' Status and Performance to Pre- and Post-PhD Career Variables

A. Long et al. (1979)—Fiscal year 1957, 1958, 1962, 1963 PhDs

Equation		PhD Rating$_1$	Postdoc Rating$_1$	Mentor Prominence$_1$
1. Prestige of biochemists' first academic job (N = 239)	b	.324**	.277**	.390*
	r	.390	.269	.342
2. $\sqrt{\text{Later publications}_1 \text{ of academic biochemists who did not change institutions (N = 134)}}$	b	.000	.001	−.011
	r	.165	.189	.159

B. Present Analysis—1969–1970 PhDs

$\sqrt{\text{Later Publications of:}}$		PhD Rating$_2$	Postdoc Taken	Mentor Prominence$_2$
3. Academic biochemists (N = 64)	b(r)	.287 (.167)	.095 (.140)	.069 (−.016)
4. Nonacademic biochemists (N = 33)	b(r)	.275 (.253)	.197 (.332)	.043 (−.018)
5. Academic electrical engineers (N = 28)	b(r)	.993* (.255)	−.037 (.143)	.394 (−.051)
6. Academic physicists (N = 42)	b(r)	.274 (.329)	.182* (.410)	−.038 (−.245)
7. Academic psychologists (N = 50)	b(r)	−.182 (.006)	−.009 (.186)	−.024 (−.107)
8. Academic sociologists (N = 72)	b(r)	.157 (.241)	.017 (.028)	.097 (.142)
9. Academic zoologists (N = 93)	b(r)	.256 (.331)	.139**(.375)	.041 (−.211)
10. Academic, all fields (N = 349)	b(r)	.241**(.235)	.118**(.310)	.108 (−.074)
11. Nonacademic, all fields (N = 192)	b(r)	.165* (.151)	.151**(.314)	.056 (.004)

Note for Part A: Dependent variable in Equation 1 is the Roose-Andersen (1970) bioscience prestige score of the first academic position (Long et al.: 819). In Equation 2 it is the square root of standardized (Long et al.: 819) journal publication levels for the three-year period ending in the sixth year of the first job. PhD rating$_1$ = Cartter (1966) prestige of the PhD department; Postdoc Rating$_1$ = Roose-Andersen bioscience prestige of fellowship location for fellows in rated departments, .358 for others; Mentor Prominence$_1$ = square root of five-year citation counts for mentor; $\sqrt{\text{pre-PhD Publications}_1}$ = square root of standardized levels of three-year publication counts ending in the first year of the first job; Selectivity of Undergraduate Institution = scale score from Astin (1971) (see Long et al.: 819); Enrollment in Graduate Department is for 1962; $\sqrt{\text{citations to Pre-PhD Publications}}$ = square roots of standardized values of citations to publications in the three-year period ending in the first year of the first job.

Note for Part B: Dependent Variable in Equations 3–11 is the square root of articles published 1975 and later. (Pearson correlation between this SCI/SSCI measure (see Table 1) and a measure that includes journal articles plus books, book chapters, and proceedings is .98 for the combined field sample.) PhD rating$_2$ is the complete score Roose-Andersen rating of the PhD department (kindly provided by C. J. Andersen); Postdoc Taken is a yes/no item; Mentor Prominence$_2$ = 1–4 scaled perception item; $\sqrt{\text{Early Publications}}$ = square root of publications predissertation and those derived directly from the dissertation; coauthor with Mentor is a yes/no item; Mentor Aid in Securing First Job = 1–5 scaled item on the dissertation supervisor's importance therein; $\sqrt{\text{Early Citations}}$ = square root of citations in 1970–1971 to work published through 1971.

stance, in an abundant market (plentiful positions for few new doctorates), active efforts by a mentor may be less important than in the opposite situation. Such conditions are apt to be quite dynamic and field-specific (witness the bust in the engineering Ph.D. market of the early 1970s and the current boom). It is interesting to note, too, that for our cohort, neither the measure of mentor prominence nor of mentor aid in securing the first job are significant predictors of later publication productivity (Table 2) or, with the exception of zoology (where mentor aid is a negative influence), of salary (Table 3).

(3) Long et al. claim that pre-Ph.D. publications are the best available predictor, at the time of receipt of the doctorate, of anticipated later contributions (Table 2, Equation 2). Our early publication measure is significantly predictive in two fields—sociology and zoology (Equations 8 and 9). Furthermore, our regressions suggest that Ph.D. institution prestige rating is salient only for electrical engineers (Equation 5). Beyond the doctorate, the taking of a postdoctoral appointment contributes significantly to the prediction of later publications for physicists (Equation 6) and zoologists, as do early citations for psychologists (Equation 7) as well as zoologists.

Equations 2 and 3 provide the most direct comparison between our results and those of Long et al. We confirm their finding of a posi-

(1977), plus the written commentary volunteered by over one-third of the respondents to our survey (see Chubin, forthcoming), show that personal vanity and accreditation of mentors do not strictly correspond to one's own eminence or lack of career success, respectively. Rather, there are continua of credit, admiration, and hostility which the passage of time and scientists' own rhetoric dulls or intensifies. Attained status alone does not predict where on those continua a scientist will fall.

Table 2. *(continued)*

$\sqrt{\text{Pre-PhD Publications}}$	Prestige of First Job	Selectivity of Undergraduate Institution	Enrollment in Graduate Department	$\sqrt{\text{Citations to Pre-PhD Publications}}$	Intercept	R^2
−4.38	—	6.67*	−4.54**	3.69	37.8	.275
.143	—	.223	.054	.221		
.394**	.003**	.059	−.001	−.022	−.188	.211
.332	.331	.167	−.027	.243		

$\sqrt{\text{Early Publications}}$	Co-author with Mentor	Mentor Aid in Securing First Job	$\sqrt{\text{Early Citations}}$	Intercept	R^2
.239 (.158)	−.152 (.060)	.108 (.133)	.009 (.086)	.825	.102
−.050(−.124)	.017 (.216)	−.285(−.281)	−.016 (.107)	.603	.251
.909 (.308)	−.027 (.184)	.359 (.288)	−.462 (.150)	−4.000	.307
.293 (.323)	.153 (.382)	.035 (.398)	.117 (.343)	−.901	.394
.297 (.378)	.555 (247)	.034 (.099)	.501**(.535)	1.127	.361
.709**(.603)	.082 (.305)	.015 (.089)	.094 (.381)	−.895	.402
.348**(.394)	.100* (.269)	−.008 (.113)	.640**(.367)	−.445	.376
.376**(.383)	.092**(.306)	.066 (.195)	.113**(.271)	−.588	.279
.227**(.238)	.066* (.222)	−.053 (.061)	.180* (.264)	−.451	.189

N = number of observations included in the regression. *r* = zero-order product moment correlations with the dependent variable; *b* = unstandardized regression coefficients; ** = $p \leq .05$, two-tailed t-test; * = $p \leq .10$, two-tailed test. Note that several of our variables are not interval scaled, hence the regression and correlation coefficients should be taken as suggestive, not definitive. Our multiple regressions were performed using SPSS's listwise deletion option. Both stepwise regressions and pairwise deletion were run for the equation predicting $\sqrt{\text{Later Publications}}$ yielding only trivial differences in the magnitudes of coefficients.

tive association between early and later publication rates (although our b is not significant), but we find that the correlation between Ph.D. institutional rating does not wash out in the regression—the b is large (though not statistically significant). On balance, our results diverge from those of Long et al. The magnitude and significance of the coefficients predicting

Table 3. Summary of Regressions Relating Salary[a] to Career Variables, by Field and Sector

Field	Academic/ Nonacademic	R^2	Major Predictor Variables[b]	Observed Influence[c]	R^2 in Salary Accounted for by Major Predictor Variables
Biochemistry	A	.156	$\sqrt{\text{Later pubs}}$	+	.107**
	N	.234	$\sqrt{\text{Early cites}}$	−	.128*
Electrical Engineering	A	.270	Mentor coauth	−	.143
	N	.029	—		—
Physics	A	.164	Postdoc, mentor aid	−, −	.045, .038
	N	.165	PhD Rating	+	.067*
Psychology	A	.274	$\sqrt{\text{Later pubs}}$, $\sqrt{\text{Early cites}}$	+, −	.121**, .063*
	N	.346	Postdoc, mentor coauth	−, −	.156**, .125**
Sociology[d]	A	.147	$\sqrt{\text{Later pubs}}$, postdoc	+, +	.053*, .047
Zoology[d]	A	.124	Mentor coauth, Mentor prom	+, −	.054**, .046**
All fields	A	.050	$\sqrt{\text{Later pubs}}$	+	.032**
	N	.067	Postdoc	−	.034*

[a] Salary = current professional income reported in 11 categories of $4000 increments (multiplied by 1.22 for those employed on an academic year basis).

[b] Criterion for inclusion is substantial contribution of the variable to overall R^2 in the multiple regression equation.

[c] + or − denotes sign of the regression coefficient or observed influence on salary.

[d] Low N for sociology and zoology academics precludes analysis.

* = $p \leq .10$

** = p of unstandardized regression coefficient of predictor variable $\leq .05$

future publications of biochemists vary even for our respective subsets of academic biochemists. The present data reveal quite different predictions of future publications across five fields of science and one engineering discipline. Interestingly, only for nonacademic biochemists does the battery of predictor variables account for more variance in later publication than it does for academic productivity (see R^2 column; nonacademic equations for other five fields not shown). Thus, the field differences in early career publication observed in Table 1 have been explored, with modest success, in Table 2. As Equations 10 and 11 show for all fields combined, this success is moderately better for predicting academics' than nonacademics' later publication. Nevertheless, this is no cause for rejoicing and further cautions against aggregating fields in future analyses.

Concerning the prediction of salary, Table 3 yields mixed results. The R^2 values are generally smaller than those for the later publication equations. For two fields (biochemistry and psychology), the salary predictions for nonacademics exceed those for academics. This is reversed for electrical engineering and there is no difference in R^2 for physics. The most consistent predictor of academics' salaries—in biochemistry, psychology, and sociology—is later publication. The early citation measure is a significant negative predictor in one academic (psychology) and one nonacademic (biochemisty) field. Two of the predictor variables are uniformly negative with single exceptions—the taking of a postdoc, in sociology, and coauthoring of at least one paper with one's mentor, in zoology. Except for these heavily academic fields, lacking a postdoc experience and not publishing with one's mentor contribute to current salary, significantly so for nonacademic psychologists.

The major conclusion to derive from our salary data is that performance norms vary by sector. This cautions against generalizing from academics to nonacademics because the reward structures of their respective employment organizations differ. Publication is not necessarily valued in nonacademic settings, and a salary earned there appears to depend on variables other than those either we or Long et al. included in our models.

Implications and Prospects

Concerning academic biochemists, our results support Long et al.'s contention that early publication predicts later publication; their observation that Ph.D. institutional prestige does not predict later publication productivity, however, is not sustained. Overall, Long et al. excelled in predicting later publication productivity of institutionally immobile academic biochemists. We excelled in predicting both the later publication and the salary of nonacademic biochemists. Perhaps the chief convergence of our respective analyses is support for the influence of "pre-Ph.D." or "early" publication on later productivity (research) and achievement (salary). If we consider other fields and institutional settings beyond biochemistry and academe, we find striking differences in pre- and early post-Ph.D. career experiences. Surely self-reports and models alone will not do. So what, we may ask, are the policy and theoretical implications of these findings?

In terms of policy, one could surmise that informal networks of communication, though neutralized in principle by affirmative action, are still extensively utilized in the placing of new Ph.D.s (e.g., Reskin, 1978). Perhaps it is time for a replication of Caplow and McGee's (1958) classic study of the marketplace, with nonacademic sectors included. Bucher and Stelling's (1977: chapter 5) observational/interview study of the professional socialization process, including a sample of doctoral biochemistry students, would be instructive for fleshing out any field-specific[4] "mentor effect" (also see Krohn, 1971; Reskin, 1979) that unobtrusive methods only begin to illuminate.

As for theoretical repercussions, instead of assuming scientists' single-minded quest for status and questioning the observance of universalism in that quest, perhaps career-patterns analysts should undertake a reappraisal of *all* the norms as they bear on the unfolding scientific career. Merton (1942, 1965) articulated a scientific ethos whose component norms engender ambivalence in the scientist and are not readily distinguishable empirically (for a review, see Stehr, 1978). Thus, while the

[4] Scientific field may not even be the appropriate level of analysis. The subfield or specialty may circumscribe a network of significant others who are used for placing new Ph.D.s in certain sectors and settings (e.g., government as opposed to medical school laboratory) (Studer and Chubin, 1980: chapter 2). Our best approximation with the present data are a series of regressions predicting "% FTE academic" by field. Again, the evidence favors field-specific interpretations. In five of the six fields, mentor variables (coauthorship with, prominence of, aid in securing first job) are the major predictors. However, the R^2 values range only from .027 (zoology) to .20 (sociology). In the latter field, mentor prominence is positively related to a career in academe; but in zoology and psychology (R^2 = .132), this is negatively related. Finally, taking a postdoc is the only significant (and positive in sign) predictor of % FTE academic in biochemistry (R^2 = .098).

prescriptive content of the norms is widely acknowledged, their descriptive content remains blurred (e.g., Barnes and Dolby, 1970; Mitroff, 1974; Mulkay, 1980). What, in short, does the operation of particularism in the placement of some Ph.D.s reflect about the hypothesized communality, organized skepticism, and disinterestedness that characterize what some (e.g., Nelkin, 1975) maintain is an academically stereotyped reward system of science?

Clearly, disparate assumptions underpin models of the scientific career (see Bourdieu, 1975; Knorr, forthcoming) and predispose analysts to certain variables, data, and interpretations. In view of our findings and those assembled by Long and his colleagues, the prospect of a continuing reappraisal of career patterns—via complementary approaches as well as data, on past cohorts as well as contemporary ones—would seem welcome indeed.

APPENDIX

A PROFILE OF THE SIX-FIELD SAMPLE

The range in response to the questionnaire extends from a low of 64.2% in physics to a high of 79.4 in zoology (76.3% in biochemistry). The number of usable responses ranges from 93 in sociology to 123 in zoology (119 in biochemistry). Comparison of our sample's characteristics (e.g., median age at doctorate, percent with master's degree, percent female) with population profiles derived from the National Research Council's Doctorate Records File and the Office of Education's *Earned Degrees Conferred* shows excellent correspondence. Our *Dissertation Abstracts*-based sample is representative of the 1969–1970 Ph.D. cohort in six fields: sociology, psychology, zoology, biochemistry, physics, and electrical engineering (see Table 1 for sample n per field). The six fields were chosen to span the National Research Council's categories of science-based doctorate holders, although we claim neither that any field is representative of a major category (e.g., physics of the "physical sciences," including mathematics, chemistry, and earth sciences), nor that any set of fields is representative of "science." When respondents were compared with nonrespondents and with those in our original sample not effectively addressed (e.g., foreign addresses, no addresses, undeliverable), no significant differences on such measures as Ph.D. institution prestige or geographical region emerged. Likewise, our initial publication counts showed a nonsignificant difference (t test) between respondents (mean = 6.46, median = 3.62) and nonrespondents (mean = 5.96, median = 2.54), but a significant one with the nonaddressed group (mean = 4.81, median = 2.12). Our respondents thus seem to overrepresent slightly those active in research. We also note that these "objective" publication counts, derived from searching the *Science Citation Index*, greatly underestimate our final tallies augmented by respondent review of our listing and subsequent rechecking as we compiled citation counts (overall sample publication mean = 9.66 vs. original tally mean of 6.46—a distressing shortfall of 33%).

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APPENDIX I

DRAFT

THE DOCTORATE PLUS A DECADE[1]

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Abstract

The preparation of a doctoral dissertation has traditionally served a dual function in graduate education: as training in and demonstration of research competence; and as generator of substantive research results. We report a study assessing the effectiveness of the dissertation in each of these roles for a sample of 107 psychologists receiving PhD degrees in 1969-70. Findings indicate that recipients are generally satisfied with the training role of the dissertation, though enthusiasm varies across specialty and career path. Dissertation research appears at least as good as other work by the same authors. Secondary findings include evidence for a clear and early bifurcation into research and non-research career paths, with the second becoming increasingly predominant when compared to an earlier cohort of psychology PhDs. Implications for research and educational policy are suggested.

THE DOCTORATE PLUS A DECADE[1]

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Porter and Wolfle (1975) reported the results of a survey, conducted in 1973, of 1962-63 psychology PhDs. Their research had been prompted by a suspicion that the dissertation might be lacking in terms of its research value and its training efficacy. That proved wrong. The 128 respondents portrayed the dissertation as a valued centerpiece of graduate training for the doctorate. Publication and citation measures of the open literature output of the dissertation showed it at least as worthy as other work produced by those psychologists over the course of their first professional decade. Respondents also gave the dissertation solid marks for training. Queried on possible alternatives to dissertation practices, they expressed considerable support for the notion of reporting the dissertation research in the form of articles. Subsets of the respondents were quite supportive of non-research-oriented variations on traditional doctoral training.

We have attempted here to replicate and broaden the inquiry as to the role of the dissertation in emergent scientific careers. This is a report of a 1979 survey of 1969-70 PhDs in psychology, augmented by observations based on concurrent samplings from five other fields (physics, biochemistry, zoology, sociology, and electrical engineering). We find many similarities and a few notable shifts in the implications drawn from this latter cohort of PhDs compared to the earlier one, both surveyed after about a decade of professional work.

A central focus in this inquiry remains the dual role of the doctoral dissertation in psychology - to provide training in research and scholarly techniques, and to yield original scientific contributions (APA, 1959; Berelson, 1960; University of Michigan, 1976). The present research assesses how well these aims were fulfilled for the 1969-70 PhDs, drawing selected comparisons with their 1963-64 predecessors. The desirability of changes in traditional doctoral requirements are assessed, producing a different image in 1979 from that obtained in the 1973 survey. We also investigate the commitment to research of the two cohorts.

Method

A questionnaire was mailed in April, 1979, to doctoral recipients randomly selected from those listed in Dissertation Abstracts. We eliminated those whose last name and initials were the same as another scientist in the National Research Council's (NRC's) combined work tape to expedite citation search. Persistent mail and telephone follow-up yielded a total of 107 usable responses, a 69% response rate based on subtracting undeliverables and misidentified individuals. The survey instrument, while based on the Porter-Wolfle one, was refined and modified to accommodate the broadened scope of a six-field study (e.g., "professional service" replaced "clinical practice" to accommodate engineering as well as psychology).

As in the earlier study we sought information on scholarly publication. Whereas in the first study we simply asked respondents to list their publications, we now provided a preliminary listing derived from the Science Citation Index (SCI) and Social Science Citation Index (SSCI), asking respondents to correct and augment it. A critical piece of information in both surveys was the respondent's classification of each publication as to its relationship to the dissertation. Additional publications for the earlier cohort over the years since their survey were compiled by a manual search of the SCI and SSCI. Citations to their works were compiled by a similar search of the SCI for the earlier cohort's first decade, and by hand tabulation from the SSCI and machine tabulation from the SCI for both cohorts through 1978.

The 1979 survey strove to minimize a response bias noted in the earlier survey (55% response rate) favoring those oriented toward research. Besides a vigorous follow-up effort to extract response, we prepared different cover sheets and publication listing sheets to make clear our interest in non-publishers, too. (This may have slightly underestimated publications by those for whom we found none in SCI or SSCI.) Comparing initial publication counts for all fields showed respondents publishing non-significantly more than non-respondents ($\underline{M}$ of 6.46 vs. 5.96; $\underline{t} = 0.76$), but significantly more than those not effectively addressed - e.g., those for whom we found no address, foreign addresses, undeliverables ($\underline{M}$ 4.81; $\underline{F} = 3.67$). Respondents seem to overrepresent slightly those active in scientific research, but somewhat less so than did the earlier survey. On other dimensions examined, respondents appeared very comparable to the non-respondents and non-addressed groups, as well as to NRC profiles of fiscal year 1970 doctorates (National Research Council, 1971) as to percentage of women, median age at doctorate, percentage engaged in postdoctoral study, and so on (Porter *et al.*, 1981).

The Graduate Training Experience

It seems reasonable to consider graduate training as a process through which individual candidates are affected in various ways. Individuals bring certain attributes themselves, such as significant family responsibilities. For example, 72% of the sample (when not otherwise specified, we are referring to the 1969-70 psychology PhDs) were married and many had children (note number of dependents in Table 1). Schools provide certain tangible (e.g., research facilities) and intangible (e.g., reputational quality rating) factors. A surprising increase in departmental quality ratings is shown in Table 1; one might have anticipated a decline as less prestigious schools built PhD programs. Overall time to complete the doctoral program process is slightly reduced from the 1963-64 to 1969-70 cohort, but time invested in the dissertation is up slightly (from 20% to 24% of the full-time equivalent months). Comparing the six fields surveyed in 1969-70, psychologists spent the least time on the dissertation.

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Insert Table 1 about here

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Despite the scientific stereotype of the PhD as a research degree, research as a career aim for psychologists slightly trailed teaching and professional practice (on a five point scale, typical for these items, anchored at 1 = not important to 5 = very important, respective medians: 3.3, 3.5, 3.7). This relates to career commitment to research, discussed in a later section.

The following factors were noted as important in selecting a particular PhD program: financial support (median 3.9), reputation of the department (3.8), situational factors (3.5), reputation of the university (3.3), reputation in specialty area (3.2), and particular faculty member (1.5). The sources of financial support during the period of dissertation research (listing a maximum of two) were fellowships (36%), research assistantships (24%), teaching assistantships (18%), spouse's earnings (20% - chiefly secondary support), and full-time employment (14%). Most notably in these times of contracting federal support, 63% said that a federal fellowship or traineeship was instrumental to pursuit of the doctorate; 44% reported a federal research grant instrumental.

Just as with selection of PhD program, a number of factors reportedly influenced choice of the dissertation topic: inherent personal interest (median 3.9), manageability (3.5), scientific importance (3.4), financial assistance/available facilities (3.1), and faculty (supervisor) preference (3.0). There is thus little evidence of undue dominance of faculty interest or financial support. Psychology dissertation topics tended to be (on scales anchored at 1 and 5): more empirical/experimental than theoretical (median 3.5); more laboratory than field (1.7); almost purely individual rather than collaborative (1.2); and basic more than applied (2.1).

Dissertation supervisors (mentors) play a large role in sociology of science attributions of influence on professional careers (Chubin _et al._, 1981). Our respondents indicate their supervisors to be strikingly eminent (Table 1), typically having guided great numbers of prior PhD dissertations to completion (_M_ 17; median 10). This implies that relatively few faculty members guide most PhD dissertations. The amount of supervision provided is substantial (median 3.7, where 4 is "moderate" on a 6-point scale from 1 = minimal to 6 = almost daily) and quite stimulating (median 3.6 on a

5-point scale from not at all to very much). In contrast, committee members are virtually invisible with supervision at a median of 1.4 on the 6-point scale and not particularly stimulating (median 2.1 on the 5-point scale). It is reassuring to report that conflict was very rare - only 22% noted even moderate conflict between any combination: student and supervisor, student and committee, or supervisor and committee.

Respondents saw their dissertations as being evaluated primarily in terms of a demonstration of research competence (Table 1). Originality and scientific contribution were seen as of substantial, though distinctly lower importance, with practical relevance and reporting positive findings rather less important. The low emphasis on positive findings is encouraging given instances in which pressure for positive findings either dissuaded attempts at significant research (Gabor, 1972) or sidetracked completion of the doctorate as when a dissertation underway was "scooped" (Porter _et al_., 1981). On the other hand, the low emphasis on relevance may reflect under-use of the significant time and resources invested in dissertations.

Evaluation of the Dissertation

The previous section has characterized the dissertation within the doctoral training process. We now turn to various indications of the value of the dissertation.

Two basic findings suggest that, for the majority, the dissertation plays only a limited career role. Few PhDs carried forward that research beyond receipt of the degree (median 1.6 on a 5-point scale). Furthermore, few would have cared to had they had support (e.g., a postdoctoral fellowship) - median 1.5. This result and regression analyses indicating that continuation of the dissertation research is not a strong predictor of later research performance counter the notion of promoting research careers through postdoc's to pursue the dissertation research, as suggested by Porter and Wolfle (1975). Consistent with these observations are the respondents' reports that the dissertation is not very relevant either to their work on their first post-PhD job (median 2.6 on a 5-point scale) or their 1979 job (2.2).

Given that the direct linkage between the dissertation and later professional work is weak, the positive evaluations of it, particularly with respect to learning to do independent research (Table 1), are noteworthy. The overall sense is that the dissertation is a generally valuable experience. As with the 1963-64 cohort, the dissertation continues to receive solid support as a training vehicle. Table 2 shows that while the dissertation is more favorably evaluated by lab psychologists, non-lab and clinical psychologists also perceive the experience positively.

Insert Table 2 about here

More broadly, respondents generally evaluated their doctoral training favorably. On 1-5 scales, choice of dissertation topic received a median 3.6; choice of specialty area, a 4.3; field of study (psychology), a 4.5; and having earned a PhD, an overwhelming 4.8.

The research merits of the dissertation will be gauged in terms of resulting open literature publications (journal articles, books, book chapters, proceedings) and citations. However, we do note that respondents' own assessment of research value is "moderate" (Tables 1 and 2). Table 3 draws upon respondents' classification of their publications and offers several comparisons. Bearing upon the research value of the dissertation, note that dissertations plus continuation of that research yield about 1 publication per person for the 1969-70 PhDs, down from nearly 2 per person for the 1963-64 PhDs. In addition the percent publishing is down, with only 32.4% of the 1969-70 PhDs publishing from the dissertation or its continuation.

Citations provide another measure of scientific merit, though an imperfect one (c.f., Edge & MacLeod, 1977), in attesting to some form of usage of a publication. Citations/year/item for the dissertation-derived publications surpass those for other publications by these authors, for both cohorts. Medians for the 1969-70 PhDs accentuate the differences: predissertation, .005 citations/year/publication; dissertation, .254; dissertation continuation, .167; later research, .007. The indication is thus lower in numbers of open literature publications based on the dissertation from the later cohort, but still of high scientific importance. In sum, one should neither over- nor under-estimate the research value of the dissertation.

Insert Table 3 about here

Evaluation of Current Dissertation Practices and Possible Alternatives

The analysis of the 1963-64 cohort (Porter & Wolfle, 1975) suggested general satisfaction with the dissertation, but also considerable support by clinicians and non-academics for potential changes. In undertaking the present study we were particularly interested in determining whether such attitudes would prevail for a later cohort questioned in 1979.

One might first wonder whether the dissertation experience was similar for academics and non-academics; and for clinicians, non-lab, and lab psychologists. The most notable replication was that full-time equivalent investment in the dissertation varied for these groups. Academics spent less time than non-academics (9.4 vs. 11.4 months); non-lab specialists and clinicians, less than lab psychologists (8.0 and 9.9 vs. 13.9). As indicated in Table 2, the different specialties each perceived the dissertation favorably.

Table 4 compares the outlooks of 1963-64 and 1969-70 psychology PhDs on several specific points of concern with respect to the dissertation and its conduct. Criteria against which to judge quality of a dissertation have traditionally included both implicit research value and training worth. That is, not only is the dissertation expected to be the vehicle to train prospective scientists, but it is meant to display success in the scientific endeavor. One perceived concern that has stimulated these inquiries into psychologists' dissertation experiences has been that originality may suffer in the demand to obtain positive results, i.e., hypothesis-confirmation. Both cohorts agree with these directions of emphasis, however the 1969-70 group is less concerned with over-emphasis on positive results.

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Insert Table 4 about here
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Several ways to ameliorate some of the perceived problems with the dissertation were explored with both cohorts. In brief, the modicum of support for some of these alternatives expressed by the 1963-64 PhDs in 1973 seems to be lacking in the views of the 1969-70 PhDs questioned in 1979. In essence, they show nothing more than a neutral stance on any of these possibilities.

We wondered if the clinicians and non-academicians might have strong views that departed from those of their peers. While they are more inclined to look favorably upon modifications in the dissertation routine, there is no groundswell of support. The sharpest deviations appear on the last two items. Clinicians are neutral on the notion of practicum experience in lieu of a research dissertation (mean of 3.0 vs. a mean of 2.3 for all non-clinicians combined). Likewise, non-academicians are more supportive at a mean of 3.1 than are academicians at 2.2. The same sort of pattern emerges with respect to the notion of alternative doctoral degrees, such as the D.A. or Psy.D. Clinicians voice modest support (mean = 3.4, vs. all others combined at 2.7). While open to the notion of change, one can certainly not conclude that these PhDs are strong advocates of it.

Early Career Research Commitment

Several aspects of the research activity during the first decade post-PhD can be addressed under the hypothesis that research is not a major concern of a majority of PhDs. Table 5 tallies the research efforts according to current work setting and specialization. The within-cohort results are not startling: academicians publish more and are cited more than non-academics; lab psychologists publish more and are cited more than non-lab, in turn more than clinicians, although the publication rates for the 1969-70 academics do not show any substantial differences. Most striking is the general drop in publication rates for the latter cohort.[2] Not displayed are comparisons by major work activity that show a more pronounced drop in publications for the latter cohort for those who categorize themselves as teachers [1963-64 PhD $\underline{M}$ 12.0 ($\underline{N}$ = 25) to 5.5 ($\underline{N}$ = 22) for 1969-70 PhDs] or administrators [M 10.4 (N = 20) to 6.0 (N = 21)] than for others [e.g., researchers and researcher/teachers - M 19.3 (N = 35) to 16.5 (N = 19)]. Also note that the latter sample, while somewhat more academically oriented, is somewhat less involved in research as their major professional activity.

Insert Table 5 about here

Figure 1 compares the profiles of publications over time for the two cohorts. Note that both show a rise, then a decline in research output.[3] Such a pattern was not observed generally for the 1969-70 PhDs in other fields surveyed (an exception is sociology); rather, publications/year increased over the course of the first decade post-PhD. Related data imply this decline to be more a function of fewer people actively engaging in research than of the same number of researchers each producing less. Also, note that the level of output is considerably lower for the latter cohort.[2,3] This decline of research output per PhD is appearing where we expected an increase in accord with increased pressures to publish and the associated "literature explosion." Scanning some of our other research indicators, we can see that the caliber of research facilities declines from graduate school to work setting (Table 1). Also, percent time devoted to research declines from 1963-64 to 1969-70 PhDs (Table 1), and it also declines from first post-PhD job to the job a decade post-PhD for both cohorts. In sum, a variety of measures suggest that the 1969-70 cohort was considerably less involved in research at the end of their first professional decade than they were at the commencement, and considerably less than the 1963-64 PhDs were after their first decade out. If psychology PhDs are abandoning research, we need to find out why, whether factors such as federal support are critical, and which work roles they are embracing.

Insert Figure 1 about here

Career research productivity can be related to aspects of the graduate training and post-doctoral experiences. Regression analyses for a variety of subgroups of the 1969-70 PhDs in six fields indicate that early publication, percent time on research in first post-PhD job, attending a prestigious PhD institution, extent to which the dissertation relates to 1979 work, research as aim in seeking the PhD, and taking a postdoctoral appointment associate with later research publications and percent time on research (Porter et al., 1981). For the psychologists taken separately, early publication and percent time on research on the first job are the significant predictors, with aim in seeking the PhD also a predictor of later percent time on research. The sense is that research orientation is established early in one's career. However, one should beware of imposing these criteria of professional attainment upon all PhDs since a substantial proportion of them do not see research as their main aim. We have explored alternative measures, including salary and supervisory responsibility, finding that these are not predicted by the same factors that predict publications (and citations) and percent time on research.

Conclusions

Several conclusions and concerns emerge from this compilation of data on 1969-70 PhDs in comparison with a similar profile for 1963-64 PhDs, surveyed respectively in 1979 and 1973. Psychology PhDs judge the dissertation to be a highly valued component of their graduate training. This judgment appears accentuated for the more recent survey. Dissertation research appears in both samples to have at least as great a scientific value in terms of publication and citation as later work by the same authors. However, on average, respondents in the new sample generated only one publication deriving from their dissertations or continuation of their dissertation research taken together vs. approximately two publications by the earlier cohort. Indeed, the latter cohort appears to be publishing less at all phases of their early careers.[2]

Attitudes toward the dissertation and its role in doctoral training in 1979 appear disinclined to making serious modifications. What looked like a potential movement toward support of alternative doctoral degree pathways in the early 1970s seems to have lost momentum.

Of course, it must be recognized that these samples represent those who have successfully attained the PhD. In a companion study (Jacks _et al_., 1981) we interviewed 25 "ABDs" - persons who have completed all doctoral requirements except their dissertation - including eight psychologists. A minority view of this group was that alternative routes to a PhD or alternative doctoral degrees should be awarded to people who do not intend to do research. Ideas advanced included the possibility that those inclined toward teaching or to clinical work ought to qualify for doctoral degrees after serving some form of internship likened to a physician's residency requirement. Others who have pursued research suggested that undertaking a PhD at this point in their careers would be a meaningless exercise since they already knew how to perform research. Most of the ABDs felt that they were as competent as holders of PhDs. However, the majority sentiment was that it would be hard to establish another route to a PhD that would be "both rigorous enough and fair" without the writing of a dissertation. One of the psychologists had, in fact, been investigating alternative PhD programs where she would not have to write a thesis; but she believed that the people she had observed who had not done dissertations were less competent researchers, at least at the outset, than those who had done so. On balance, neither the PhDs nor the ABDs surveyed are generally supportive of movement away from the dissertation as the basis for the doctoral degree.

With the advantage of hindsight, our psychologists might recommend that a good dissertation experience begins with careful choice of the topic, with particular attention paid to scientific importance. The imposition of evaluative pressures for significant and original work, though not for positive and/or relevant findings, are associated with more highly valued dissertation experiences. Selecting a prestigious department is slightly associated with a less pleasant dissertation experience, though very slightly associated with enhanced career research productivity. The eminence of one's dissertation supervisor shows little or no relation to how satisfactory the dissertation experience is, though it does show a moderate correlation with career publication rates. A favorably evaluated dissertation experience associates with a productive research career to a moderate extent. These linkages indicate that the dissertation is an important element in the development of a research career. Clearly, choices affecting it should not be taken lightly, particularly as they represent a sizeable investment, on the order of ten full-time equivalent months of one's life.

Synthesizing the above conclusions illuminates some directions for needed action. For one, there may be a growing misfit between graduate training which emphasizes research through the dissertation and professional careers that do not pursue research. Present results are rather paradoxical. While only a minority of psychology PhDs (and those in other sciences) actively pursue research careers, the majority sentiment is that we should not tamper with the research-oriented doctoral training process. They may be right - completing a dissertation may be the optimal way to train for teaching and clinical careers, as well as research careers. Alternatively, perceptions may be influenced by a prestige pecking order that places research careers in science at the top, and/or tight job markets that place premiums on "high" credentials. We suggest that psychologists may more actively have to market their skills in non-academic settings, in the process rethinking graduate training that follows a traditional academic imagery. On the other hand, tight job markets may preclude innovation in degree programs if these take on an aura of being second class. That may be what happened during the 1970s. There appears to be a need for enhanced understanding of measures of non-research productivity and of the factors that contribute meaningfully to teaching, professional service, or other endeavors pursued by doctorate-holders.

There are signals that psychology may be in the process of undergoing radical change. Its status as a science growing through a cumulating research base may be severely challenged; the present disquieting data on declining research activity need to be verified by other means. The profession should take a hard look at the implications of this and act accordingly in terms of developing alternative sources of research support, and/or, considering, as necessary, alternative career models and their educational requirements.

Footnotes

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[2]As noted, in the more recent survey we reduced the non-response rate and the tendency of respondents to be more prolific publishers than non-respondents,observed in the earlier survey. This confounds research comparisons of the two cohorts, but to what degree? As a hypothetical computation, assume the 69% response rate includes a group similar in research orientation to the 55% respondents of the earlier cohort who averaged 9.4 publications in 8-9 years post-PhD. Assume further that the additional respondents average only 1 publication in 8-9 years post-PhD. The result is an average of 7.7 publications, accounting for only half of the observed difference in that the 1969-70 cohort averaged only 6.2 publications. (This includes only journal articles, books, book chapters, and proceedings, but it does so for all 106 respondents, so the tally differs from Table 5.) It appears that there is a decline in research activity not explainable even by an extreme interpretation of the sampling difference.

[3]To assure that the cross-cohort comparisons were not flawed by methodological differences and to extend the time period through 1980, random samples of 20 from each cohort and 20 1969-70 biochemists were

tracked using SCI only. The general profiles are confirmed as the old cohort dominates the new (if one plots in terms of years post-PhD, this dominance begins 3-4 years out) and the downtrend extends through 1980 for both groups of psychologists. In contrast, the biochemists exhibit an upward trend over the decade.

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Table 1

Graduate Training and Early Career Profiles of 1963-64 PhDs and 1969-70 PhDs

Item	1963-64 PhDs	1969-70 PhDs
Basic Information		
N Respondents	128	107
Percent Women	18.0%	24.3%
Mean Dependents Just Prior to PhD Receipt (not including self)	1.7	1.5
Graduate School		
Quality Rating - percent from good to distinguished programs[a]	24%	40%
Time:		
Mean Full-Time Equivalent (FTE) Months on the Doctoral Program (Median)	48.5 (~47.0)	43.0 (44.9)
Mean FTE Months on the Dissertation (Median)	9.5 (7.7)	10.3 (9.5)
Adequacy of Research Facilities:		
Dissertation Period - Mean (Median) (1 = not satisfactory to 5 = very satisfactory)	3.7 (3.8)	3.9 (4.1)
Current - Mean (Median)	3.2 (3.4)	2.2 (2.1)
Dissertation		
Supervisor Prominence - percent Eminent or Renowned[b]	41%	45%
Evaluation of One's Own Dissertation		
Originality	3.8 (3.9)	3.4 (3.5)
Significant Contribution to Science	3.2 (3.2)	3.3 (3.3)
Positive (Rather Than Negative) Findings	2.5 (2.3)	2.8 (2.9)
Relevance		2.6 (2.5)
Demonstration of Research Competence		4.2 (4.4)
Value of Dissertation with Respect to: (1 = not satisfactory to 5 = very satisfactory)		
Research Findings - Mean (Median)	2.7 (2.7)	3.1 (3.1)
Learning to Do Independent Research	3.7 (3.9)	4.2 (4.3)
Learning Specific Research Skills	3.0 (2.9)	3.4 (3.6)
Generally Valuable Experience	3.3 (3.5)	3.8 (3.9)
Early Career		
Carried Forward Dissertation Research[c]	39%	21%
Psychology Is Still Professional Identification Some 9 Years After the Doctorate	95%	94%
Percent Time Devoted to Research - Mean (Median)[d]	22% (17%)	19% (10%)

[a]1963-64 data are Cartter (1966) ratings showing 13% attended extremely attractive programs; 11%, attractive ones; 34%, "acceptable plus" programs; and 41% "other" programs. 1969-70 data are Roose-Andersen ratings (1970) on rated quality of the graduate faculty with 8% from strong to distinguished programs; 32%, good to strong; 45%, adequate to good; and 14%, marginal. Ten did not attend rated programs; if these are lumped into the bottom category, the percentage rises from 14% to 22%. (Charles Andersen of the American Council on Education kindly provided explicit scale scores and recommended this measure as more valid than rated effectiveness of doctoral programs, with which it is highly correlated.)

[b]1963-64 data on a 5-point scale: top 5% (33); very eminent (18); established (35); "up and coming" (23); not prominent (16). 1969-70 data on a 4-point scale: renowned - top 5% (21); eminent - top 20% (26); established (45); not prominent (13).

[c]1969-70 responses on a scale from 1 = not at all (49); 2 (18); 3 (19); 4 (12); 5 = very much (6). Percent computed as 4 and 5 responses/1, 2, 4, 5 responses.

[d]1963-64 responses were in hours/week on various activities. Values shown are the hours for research (mean 11.4, median 5.8) divided by the total hours indicated for research, teaching, attending classes, administration, and counseling/consulting.

Table 2

Ratings of Dissertation Value by Specialty Area

Dissertation Valuations	"Lab" Specialties[a] (mean)	"Non-Lab" Specialties[b] (mean)	Clinical (and Counseling) (mean)	Difference Between
	(N=26)	(N=24)	(N=47)	
Research Value Index[c]	3.47	3.29	2.99	F=2.06; n.s.
Training Value Index[d]	3.91	3.71	3.54	F=1.38; n.s.
Generally Valuable Experience	4.35	3.58	3.70	F=3.78; p=.026

Note.- For each measure, "1" = "not satisfactory"; "5" = "very satisfactory."

[a] experimental, physiological

[b] e.g., developmental, educational, industrial, psychometrics, social, general/other

[c] Evenly weighted composite of perceived research value of dissertation, satisfaction with topic, and inclination to pursue the research post-PhD.

[d] Evenly weighted composite of satisfaction with learning to do independent research, specific research skills, to write for scholarly publication, and other valuable professional skills.

Table 3

Scientific Productivity by Research Period

	Research Period									
	Pre-Dissertation		Dissertation		Continuation of Dissertation		Other Later Work		Total Through "First Professional Decade"	
Item	1963-64 PhDs	1969-70 PhDs	1963-64 PhDs	1969-70 PhDs	1963-64 PhDs	1969-70 PhDs	1963-64 PhDs	1969-70 PhDs	1963-64 PhDs	1969-70 PhDs
M Publications[a]/Person	1.19	0.81	0.65	0.42	1.33	0.52	5.57	4.00	9.38	6.15
Percent of Respondents Publishing[a]	36	45	42	28	25	17	65	54	78	65
Citations[b]	398	(203)	454	(225)	311	(132)	643	(995)	2337	(1859)
M Citations[b]/Year[c]/Respondent	0.47	(0.25)	0.65	(0.31)	0.63	(0.28)	1.52	(2.13)	4.01	(3.49)
M Citations[b]/Year[c]/Item[d]	0.34	(0.31)	0.63	(0.74)	0.52	(0.57)	0.32	(0.62)	0.38	(0.51)

Note.- Research period tabulation based on 110 of the 128 1963-64 PhD respondents in 1973 survey, and 102 of the 107 1969-70 PhD respondents in 1979 survey, for whom research period of their publications was provided. For the total column, additional data are incorporated to yield a best estimate: 100 published, incorporating an updated search on the 128 respondents in SCI and SSCI source indices back into the 1960's, so use *N* of 128. Total is greater than the sum of the four columns because research period is unknown for some publications. Total publications/person is taken as 1126/120 for the 1963-64 cohort (excluding 8 publishing beyond our data base); 658/107 for the 1969-70 cohort.

[a]Publications include only journal articles, books, book chapters, and proceedings - a more restricted count than that reported originally by Porter and Wolfle (1975) for the 1963-64 PhDs. The tally runs through 1972 for the 1963-64 PhDs and through 1978 for the 1969-70 PhDs.

[b]Citations counts for the two cohorts are not comparable; the new tally includes self-citations, and the coverage is greater as Science Citation Index expanded and Social Science Citation Index is included, but the automated counting of SCI showed a substantial rate of missed citations. Tallies are citations through 1972 for the 1963-64 PhDs and through 1978 for the 1969-70 PhDs.

[c]Citations/year computed as citations/[78 - year of publication] for the 1969-70 cohort with years prior to 69 set at 69; similarly for the 1963-64 cohort the denominator is [72 - year of publication] with publication years prior to 64 set at 64.

[d]Item includes any publication tallied (e.g., reports, abstracts, papers presented). For the 1963-64 cohort, the total is 1287 (vs. 1126 publications as per the more restrictive definition of Note a); for the 1969-70 cohort, the total is 777. (However, fewer are relevant for these calculations because of exclusions, such as 1978 publications allow no time for citation.)

Table 4

Evaluations of Current Dissertation Practices and Possible Changes by 1963-64 PhDs and 1969-70 PhDs

	1963-64 PhDs Mean (Median)	1969-70 PhDs Mean (Median)
A. <u>Evaluation of Current Emphases</u>		
(For 1963-64 cohort: 1 = greatly reduce; 5 = greatly increase		
For 1969-70 cohort: 1 = too much 5 = too little)		
Emphasis on Originality	3.3 (3.3)	3.6 (3.4)
Emphasis on Positive Results	2.0 (1.9)	2.6 (2.7)
Emphasis on Relevance of Dissertation to Student's Career Needs	N.C.	3.5 (3.4)
B. <u>Evaluation of Proposed Changes</u>		
(1 = strongly disapprove; 5 = strongly approve)		
Overall Increase in Standards and Requirements	N.C.	2.8 (2.8)
Several Small Scale, Original Research Exercises in Lieu of the Dissertation	2.2 (2.1)	2.6 (2.6)
Research as at Present, but Several Short Reports, More Like Articles	3.5 (3.8)	2.8 (2.8)
Extended Practicum or Internship Activities to Acquire Professional Skills that are not Research Oriented, in Lieu of the Dissertation (within a PhD program)	3.0 (3.4)	2.6 (2.1)
The Option of Alternative Doctoral Degrees (e.g., Doctor of Arts) Not Oriented toward Research	3.2 (3.6)	3.1 (3.2)

Note.- (N.C.): Comparable data not collected.

Table 5

Publication and Citation Frequency by Position

Item	N 1963-64 PhDs	N 1969-70 PhDs	M Publications/Person 1963-64 PhDs	M Publications/Person 1969-70 PhDs	M Citations/Person 1963-64 PhDs	M Citations/Person 1969-70 PhDs
Position						
Nonacademic						
Clinical/Counseling	45	23	5.1	2.7	4.5	6.6
Other	24	16	7.2	4.4	9.5	6.5
Subtotal:	69	39	5.8	3.4	6.2	6.6
Academic						
Clinical/Counseling	17	12	12.0	9.0	12.2	19.6
"Non-lab"	19	12	16.2	12.5	23.9	23.2
"Lab"	21	10	20.9	8.8	61.3	39.0
Other	1	14	(0)	9.9	(0)	30.7
Subtotal:	58	48	16.4	10.1	33.6	27.8
Total	127	87	10.6	7.1	18.7	18.3

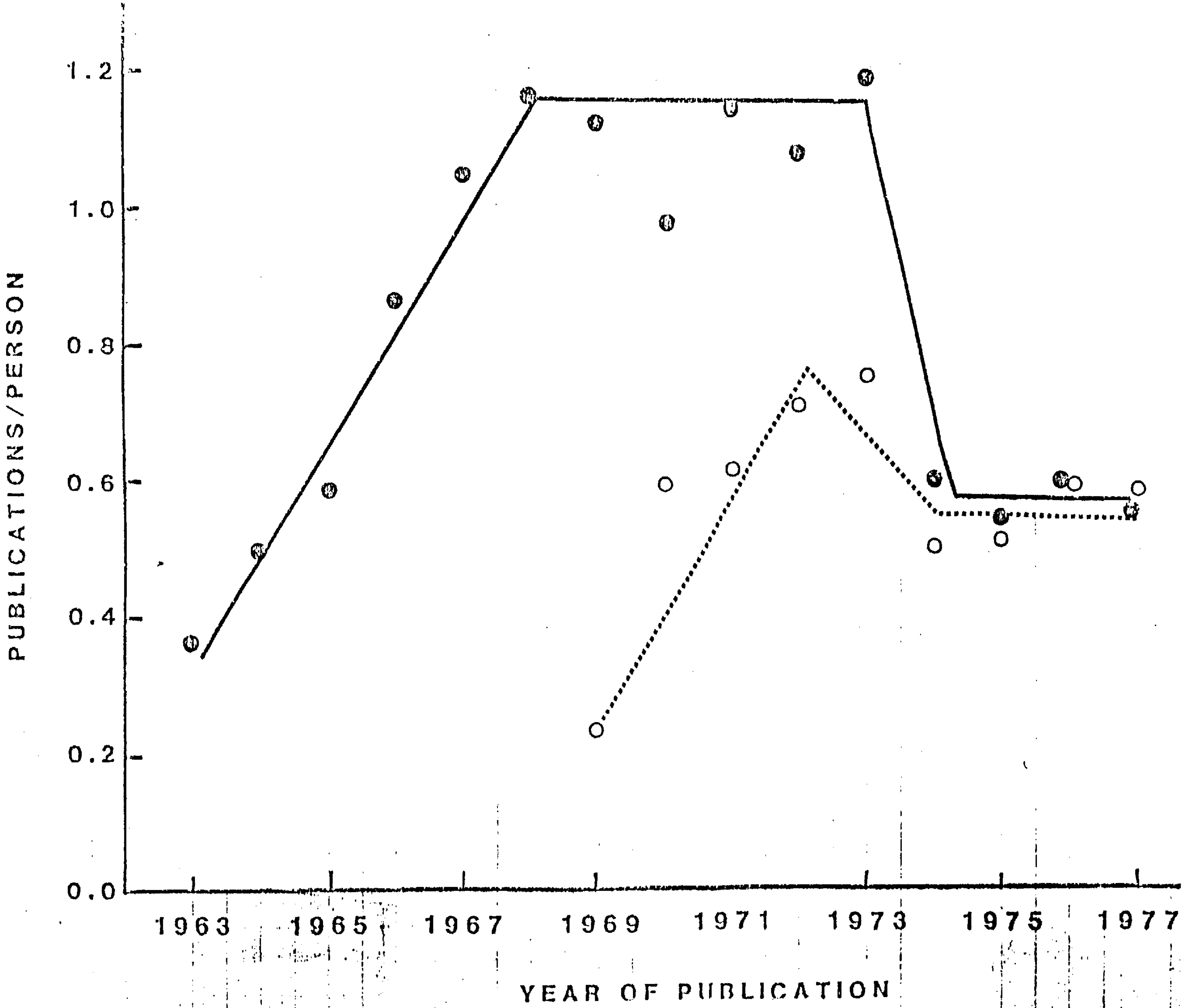
Note.- Definitions vary slightly. "Academic" for the 1963-64 PhDs is restricted to professorial appointments. Academic classification is inferred for the 1969-70 PhDs if 70% or more of the full-time equivalent years since PhD were denoted as academic; non-academic was inferred if 30% or less (mid-range being excluded here). "Lab" = physiological and experimental for both samples, plus learning for the 1963-64 PhD sample and physiology for the 1969-70 sample. "Non-Lab" = developmental, educational, industrial, personality, psychometrics, and social for both; plus engineering psych for 1963-64 and personnel, school, and comparative for 1969-70. The years since PhD approximate 9 in both cases. All publications are tallied. Citations are not comparable across cohorts; the new tally includes self-citations, and the coverage is greater as Science Citation Index expanded and Social Science Citation Index is included, but the automated counting of SCI showed a substantial rate of missed citations.

Figure Caption

Figure 1. Yearly Publication Rates

Legend: ●———————— 1963-64 Psychology PhDs

○························ 1969-70 Psychology PhDs


PUBLICATIONS/PERSON
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1963
1965
1967
1969
1971
1973
1975
1977
YEAR OF PUBLICATION

26. Nevertheless, Zuckerman (1977:106) allows that the procedures of nomination and election specific to the Nobel prizes may favor the scientific offspring of Nobelists in the sense that laureates are likely to be skillful advocates of their candidates and having permanent rights to nominate, acquire experience and judgment about the kinds of documents that must be submitted to make their case. Skillful advocacy, of course, amounts to a rhetorical manipulation of "the facts" so as to reflect most favorably on the accomplishments of the Nobel candidate. See Kash et al. (1972) and Boffey (1975) for similar evidence on election to the National Academy of Sciences.

27. As one reviewer of Scientific Elite says about Zuckerman, "her brand of functionalism if Pollyannish and uncritical" (Rosenblum, 1979:675).

28. It is past due to point out that the talent completing graduate study occupies the right tail of the distribution of intellectual aptitude in the general population. The range in intelligence (IQ) is rather restricted, extending from a lower bound of perhaps 115-120 to an upper bound of "genius" (variously defined as 150 +). The "sacred spark" of creativity (Cole and Cole, 1973) that differentiates gifted talent from the rest, therefore, may be motivation, the distribution for which is unknown, or at best, poorly measured. As proxies for motivation, elapsed time between receipt of baccalaureate degree and receipt of Ph.D. and undergraduate grade point average have been used (see Folger et al., 1970).

29. Zuckerman (1977:123) concludes that in terms of social stratification, the laureates' students "were being socialized for positions in the aristocracy of science. Seldom explicit, this was often tacitly understood...[W]ith few exceptions, they would become very good rather than run-of-the-mill scientists."

A Possible Difference in Women's Aims in Obtaining the PhD

Alan L. Porter
Patricia McBride
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Recent Comments by Dennis, Sherrill, Sollod, and Wittig (all 1979) have taken up the issue of attrition of male and female PhD students posed by Hirschberg and Itkin (1978). In particular, attention has focused on possible reasons for the differential attrition rates of men and women. Hirschberg and Itkin looked at individual differences as predictors of successful completion of a PhD program. They found relatively few differences among men and women on variables related to obtaining a PhD but a striking difference in actual attainment of the degree (35% of the women vs. 68% of the men in their University of Illinois sample of 1965–1970 graduate students completed the PhD). Rather than individual characteristics, Sollod and Wittig suggest that features of the graduate program may be the critical factors. We wish to contribute some evidence to this side of the discussion from a complementary data base.

We are presently engaged in a study of the implications of various characteristics of graduate programs for professional careers, particularly with respect to the conduct of doctoral dissertations. We have completed a national survey of 1969–1970 PhDs in six science-based fields concerning their doctoral training experiences and certain subsequent career features (e.g., publications, employment position characteristics).[1] Specifically, we would like to consider information provided by 81 male and 26 female psychology PhDs ("successes" according to Hirschberg and Itkin). Results speak to a key point of concern.

The hypothesis inferred from the comments of Sollod and Wittig is that characteristics of the graduate programs, more than personal characteristics of female PhD students, discourage their attainment of the doctorate. If this is the case, one would expect to see it reflected in the descriptions and perceptions of women who have obtained the PhD. If the key explanation resides within the women themselves, one would expect to see relatively small differences between those "unusual" women who do achieve the PhD and their male counterparts. On the other hand, if the programs do treat women and men differently, the perceptions of male and female PhDs should reflect such differences. (Obviously, one must be cautious in interpreting retrospec-

[1] This research is supported by the Division of Science Resources Studies of the National Science Foundation (Grant SRS-78 18959). The six fields covered are biochemistry, electrical engineering, physics, psychology, sociology, and zoology. Further information on the study can be obtained from Alan Porter.

23. There appears to have been only one attempt to construct a kinship tree (forest?) for an entire discipline, namely, physiology (Gerard, 1958; but see Crowley and Studer, 1975). That study was designed, however, to encompass only the "institutional and personal genealogies for most departmental chairmen and presidents of the American Physiological Society" (Gerard, 1958:269), rendering the impact of the great majority of doctoral recipients on the discipline unknown. A preoccupation with founders and disciples, the eminent and visible, has yielded fascinating portrayals of "coherent groups" (e.g., Griffith and Mullins, 1972; Krantz, 1971; Mullins, 1973), but engendered no comparable evidence on less manifestly successful scientists. Relationships involving dyads and other small groups of "trusted assessors" (Chubin, 1975) formed through mentor-student, local colleague, and cosmopolitan research (i.e., collaborative) ties would seem to constitute a more representative sample of experiences (examined below) among the rank-and-file Ph.D. population.

24. Two decades ago, Berelson (1960) observed that the reputation of one's graduate degree-granting institution leaves an "indelible mark." Over the life-cycle of a career, the mark will fade, but seldom does it vanish completely, acting for many as an expedient to achieving certain goals, and for others as an impediment to achievement (Chubin, 1974).

25. Besides this broad definition of "student," some details are instructive: (1) the percentage of American laureates with laureate masters varies from 43 percent in physiology-medicine to 61 percent in physics, and (2) the rate of laureates who have had laureate "kinfolk" has remained at 48 percent since 1925 (Zuckerman, 1977:100).

tive data on such value-laden isssues; nevertheless, the results are interesting.) Our evidence suggests that a particular individual difference, namely, orientation toward research, could be an important factor influencing the relative proportions of women and men who obtain the PhD.

In general, our present results are consistent with the observation of others such as Hirschberg and Itkin (1978) that male and female graduate students in psychology tend to be more alike than different on most factors. The first part of Table 1 shows perceptions of men and women on six dimensions that pertain to the graduate school environment. Women seem to fare well in terms of financial support, peer support, and supervisory support. Generally similar results were obtained on items relating to choice of graduate school (with the exception that women's choice was more situation dependent; 61.5% of women noted this as important vs. 47.5% of the men), interaction with dissertation advisory committee, and a variety of other factors. The only significant difference noted in this section of the table pertains to men's finding their dissertation research facilities more adequate.

This last point leads into consideration of a potentially significant difference between male and female graduate students in psychology. As indicated in the second section of Table 1, on dimensions ranging from intent in seeking a PhD through early career publication history, women appear less inclined toward research. A plausible (but unproven) extrapolation from these findings on PhDs would be that female graduate students who do not attain the PhD may share a lesser inclination toward research. If this is indeed the case, it could contribute to women's leaving a PhD program. For instance, preparation of the dissertation could become a more onerous task for persons disinclined toward research (cf. Item 8 in Table 1). The last three items in Table 1 suggest that women who accomplish the PhD are satisfied with it and with their area of training, despite lower income levels relative to their male counterparts.

The causal linkage between a disinclination toward research and failure to complete a PhD program is not proven by these findings. The present survey entails the reflections of a national cohort of male and female PhDs; noncompletion rates were derived elsewhere. Sex is certainly a complex mediating variable as well. Further study as to whether the graduate school environment discourages women from research, on a relative basis, is needed. As a working hypothesis, however, the present results suggest that individual inclination toward research could be an important determinant of success in completing a PhD program, and women appear to be less inclined toward research. This is certainly not to say that sexist treatment does not exist and need attention in its own right (cf. Fields, 1979).

These findings suggest the potential value of probing deeper into the individual motivations that cause people to seek a PhD. Better understanding of the range of individual intents could lead to suitable adjustment of graduate programs to meet legitimate student needs. For instance, one suggestive finding from our survey is that a majority of the women's responses to a question concerning the desirability of offering alternative doctoral degrees (e.g., PsyD, DA) that reduce the dissertation research requirement were supportive (52.4% for women vs. 42.3% for men). For persons oriented toward professional practice or teaching, the PhD with its dissertation requirement may not represent the optimum path to professional license.

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TABLE 1

Survey Responses of Male and Female PhDs Regarding Graduate Training Experience, Research Orientation, and Satisfaction With PhD

Variable	Men: % negative responses	Men: % positive responses	Significant difference?[a]	Women: % negative responses	Women: % positive responses
Some perceptions of the graduate school environment					
1. Primary financial support during dissertation research:					
—fellowship		34.2			42.3
—research or teaching assistantship		27.6			30.7
—other		38.2			26.9
2. Extent of help from other graduate students[b]	55.7	21.5		44.0	36.0
3. Extent of supervision by dissertation supervisor[c]	44.4	55.6		40.0	60.0
4. Coauthor with supervisor[d]	56.3	43.8		53.8	46.2
5. How important supervisor was in obtaining post-PhD work[b]	67.5	20.0		65.3	19.2
6. Adequacy of dissertation research facilities[b]	1.3	79.7	*	15.3	53.9
A personal difference? Research orientation					
7. A research-oriented career as aim of obtaining PhD[b]	33.8	51.3	*	56.0	36.0
8. Dissertation perceived as a valuable experience[b]	8.8	65.0	*	19.2	42.3
9. Dissertation work carried forward later[b]	59.5	19.0		61.5	11.5
10. Research, research and teaching, or development/design noted as primary work activity					
—first year post-PhD		37.0	**		11.5
—current (1979)		21.0			12.5
11. Adequacy of current research facilities[b]	34.4	44.3	*	68.8	25.0
12. Published 3 or more articles[e]	46.9	53.1		61.5	38.5
Other items of interest					
13. Satisfied with having earned a PhD[b]	0	92.5		3.8	88.5
14. Satisfied with choice of specialty area of doctoral training[b]	11.2	78.8		15.4	65.4
15. Current income: under $20,000 (negative); over $28,000 (positive)	13.9	51.9	**	34.6	23.1

[a] The statistical significance of the difference between the responses of men and women was examined by a chi-square test, using a large-sample approximation for the test statistic. Tests in first two sections are two-tailed; those in last section are one-tailed because a specific hypothesis was reflected there. * $p < .05$; ** $p < .01$.

[b] Responses on a 5-point scale clustered as 1 or 2 (i.e., very negative or negative) and 4 or 5 (i.e., positive or very positive), leaving out neutral responses, not applicables, and no replies.

[c] Responses on a 6-point scale clustered as 1, 2, or 3 (minimal supervision to supervision only at initial and final stages) and 4, 5, or 6 (moderate to almost daily attention).

[d] Yes–no questionnaire item.

[e] Publication record based on respondents' correction of a list compiled by us from the *Science Citation Index* and the *Social Science Citation Index* publication listings. Includes all publications noted.

APPENDIX K

UNDERSTANDING TIME TO THE DOCTORATE

Emanuel M. Tornquist, III

Alan L. Porter

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Introduction

The doctorate, explicitly the PhD - demands a major investment of both individual and educational system resources. This is epitomized in the time invested to obtain a PhD. In days of scarce resources, especially financial resources, decreasing the time to the PhD could be an important mechanism to conserve those resources. Time is also a major consideration in days of changing job markets wherein students have to consider carefully the advantages and disadvantages of seeking a doctorate. On one side at the present, the humanities, social sciences, and certain physical sciences face a dearth of PhD job opportunities. On the other, engineering, in particular, faces such riches of job opportunities, with or without a PhD, that the devotion of a number of years to attain a PhD makes no economic sense.

It has been more than two decades since the doctorate holders in Wilson's classic study [14] completed their doctoral studies in the late 1950's. Since then conditions for doctoral education and career opportunities have changed drastically. This study was prompted by a desire to see the degree to which his findings and those of others would be confirmed empirically on a more recent sample of science PhD's, 1969-70 graduates surveyed on their graduate training and early career experiences as of 1979 [11]. This study sought to resolve a number of empirical issues, including: how long does a dissertation require? how much time is devoted to attaining a PhD? and, how long does it typically take to move from a bachelor's degree to the doctorate? Secondly, attention was directed to what factors affect these times. Improved insight into these matters could illuminate exactly how much is at stake. Insight into the causal mechanisms behind the time commitment might then suggest possible courses of action for educational administrators and prospective graduate students to pursue.

Abstract

This empirical study reports time spent on the dissertation, in doctoral programs, and elapsed from the bachelor's to the PhD. Models to predict time, a critical descriptor of graduate training, are explored. Women do not take longer and federal support does not shorten the full-time doctoral training period.

[6]. Likewise, several previous studies suggest that changing fields between the bachelors and doctoral degrees extends ELT [1, 6, 14]. In a side observation, it has been noted that "hard" (i.e., physical) scientists shift fields less than do the "softer" (i.e., social) scientists [6].

The relationship of the sex of the student and time to the doctorate is an intriguing one. Evidence supports the notion that women take longer than men to attain the doctorate; the question is whether this simply reflects a confounding of other factors, or is really a significant finding in itself. Some of the potentially important confounds are field (women tending toward the social sciences and humanities), career goals (women emphasizing teaching more than do men), and faculty and peer support [1, 2, 5, 14].

Financial aid is of considerable importance in that it is one of the factors amenable to policy influence. Prior studies suggest that financial aid shortens time to the doctorate, and that it is most instrumental for the physical sciences [4, 6, 9, 14]. Another area subject to direct control is the nature of the dissertation. The emphasis placed on the dissertation, the timing of beginning the dissertation research, and the form of the dissertation (i.e., theoretical vs. experimental/empirical, laboratory vs. field, and individual vs. collaborative) all have logical and some empirical [12, 14] grounds for hypothesized influence on time to the doctorate. As with many of the factors mentioned, confounding with field differences may be important here. Wilson [14] notes that "hard" science dissertations tend to address better defined problems, demand research competence in specialization rather than "mastery of knowledge," more often relate to project research support, are less frequently conducted off campus, and tend to be shorter. Because field tends to be such an important confound, the

Conceptual Framework

Earlier studies of doctoral holders suggest a number of interesting hypotheses concerning time and the doctorate [1, 6, 14]. The first issue that must be addressed, however, is exactly what is meant by time. For purposes of this study, time is considered in three distinct terms:

1. ELT - The total elapsed time in years from awarding of the bachelor's degree to the awarding of the doctorate.

2. FTE Doctorate - The total full-time equivalent spent in the doctoral program in years, from acceptance to awarding of the doctorate.

3. FTE Dissertation - The total full-time equivalent spent on the dissertation in years, from formal approval of the dissertation topic to final approval of the dissertation.

A number of factors have been considered as possibly influential on the time to the doctorate. Table 1 summarizes those factors to be investigated in the present study, with an indication of which earlier studies closely relate to those factors and the hypotheses framed.

Table 1 about here

Wilson's study [14] is the main source of scholarly information on various attributes of a student's personal situation and time to the doctorate. In addition to finding that those students with three or more dependents tended to take longer to complete the dissertation, Wilson examined marital status (as does this study, though with no a priori hypotheses as to effects of marriage on time). The scholarly norm seems to be to discourage students from continuing on for their doctorate at the same institution as they received their bachelor's (and possibly master's degrees). Empirical evidence suggests, however, that institutional transfer extends ELT those scientists with unique names to counter the homograph problem and the sample was randomly reduced to 200 subjects per field. A response rate of 70.0% was elicited from the resulting sample for whom addresses were obtained and questionnaires were apparently delivered (i.e., excluding those for whom addresses were never found, those returned as non-deliverable, and a few mis-identified as to field or year of degree). Comparison of respondents with nonrespondents and with those for whom addresses were not effectively found showed only a slight over-sampling of those active in research in terms of identified publications. On all other terms, the non-respondents appeared similar to the respondents, and the respondents matched overall population characteristics as determined by the National Research Council extremely well [8, 11].

Study Results

This study took a two-fold approach to investigate the hypotheses put forth in Table 1. First, various subgroup means were compared in a straightforward fashion. To take account of a major source of interaction, all of these comparisons also considered the groupings within fields as well as across all fields combined. Second, multivariate analyses were conducted. Because hypotheses had been formulated that indicated causal priorities, a path analysis approach was used instead of, say, simple multiple regression.

Table 2 presents the results of the simple comparisons of means using analyses of variance (SPSS subroutine ANOVA was the primary vehicle for the analyses). Overall results indicate that for this sample of scientists the mean elapsed time from the bachelors to the attainment of the PhD was 8.1 years. Of course, there is no logical sampling framework to suggest that this sample, or almost any other, is truly representative of the sciences. This is simply an aggregation across six fields that span the National Research Council main analyses to be described break it out for each comparison drawn. In addition, there are explicit hypotheses that the physical sciences have shorter times to the doctorate than do the social sciences.

Career goals are of interest in that they bear importantly upon the valued content of a doctorate training program. PhD requirements as set up lean heavily on the notion that the PhD is a research degree; hence, considerable emphasis and time are devoted to the dissertation. Prior evidence suggests that those oriented to teaching take longer to complete the doctorate [1, 14]. If confirmed, such results imply that alternative doctoral programs (i.e., doctor or arts, doctor of psychology) that eliminate the dissertation requirement might be advantageous to such persons. Likewise, the authors extend this question to those whose interest in the doctorate stems from a career goal of professional practice, rather than research.

Graduate student employment is an important factor that interacts significantly with the availability of financial aid. Specifically, it is hypothesized that students with employment related to the dissertation topic have shorter ELT and FTE doctorate than those who do not.

The Sample

This investigation was conducted in conjunction with "a cross-disciplinary assessment of the role of the doctoral dissertation in career productivity," an NSF-supported investigation of doctoral training in six fields - physics, biochemistry, zoology, electrical engineering, psychology, and sociology [11]. The pertinent data were obtained from a mail survey of 1969-70 doctorate recipient conducted in 1979. This sample was identified through doctorate recipients listė in Dissertation Abstracts, randomly selected with an equal number per field. The National Research Council matched these names against their files to identify

Indeed, the values for four or more dependents tend to be lower than for fewer dependents - FTE doctorate means not shown are 3.2 for four dependents, 3.4 for five, and 3.5 for six; FTE dissertation means are 1.4 for four dependents, 1.0 for five, and 1.8 for six. The increase in ELT with number of dependents is almost tautological; it simply takes time to accumulate dependents, regardless of any inclination to attend graduate school.

Institutional transfer and field shift both show the suspected elongated ELT. Neither FTE doctorate nor FTE dissertation increase with such changes. Moreover, FTE dissertation even shows a reduction for those who have shifted fields since their bachelors. This might be interpreted in light of the essential equivalence of the FTE doctorate as implying that students who shift fields take longer to reach the stage of dissertation research readiness, but then they have clearer notions of their intents. It is also worthy of note that the interaction between field and field shift is sharp; the physical sciences generally have far fewer students with undergraduate degrees not directly related to their doctorate. For instance at the extremes, 93% of the physics PhDs obtained their bachelors in physics, whereas only 29% of the sociologists had theirs in sociology, with another 35% in psychology or some other social science.

Sex of the student was found insignificant in its influence on each of the three time measurements. In no individual field were differences significant. Exclusion of education and humanities from this study is likely to account for much of the discrepancy with past studies showing that women take longer because those fields have higher percentages of women and also longer times to the doctorate. It may also be that the increase of women in all doctorate fields over the past decade is reducing the influence of sex of the student in the graduate school experience. With respect to career goals, scientific discipline catagories. Field by field results are representative and merit careful considerations. Before moving down to that level of analysis, Table 2 shows that completion of the doctorate typically takes somewhere on the order of 3.7 years, of which 1.5 years - 40% - are devoted to the dissertation. Field differences are highly significant and rather intriguing. In terms of the dissertation, the natural sciences take almost two years while the social sciences and engineering take roughly one year. However, in terms of elapsed time (ELT), the difference essentially disappears. Indeed, sociology has by far the longest time from bachelors to doctorate, presumably due to interrupted educational training. FTE doctorate may be the weakest of the three time measurements because of the uncertainty in how individuals include or exclude masters degree time requirements, and about 75% of the respondents do have masters degrees.

Field was found significant in interacting with financial aid, field shifting, dissertation characteristics, and sex of student. It is particularly interesting to note the relatively low times associated with psychology. This confirms results obtained earlier [14, 8]. However, no fully satisfactory explanation has been offered for this.

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Table 2 about here
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Personal situation shows ELT nonsignificantly longer for married students and significantly longer as the number of dependents increases (not shown are means of 10.8 for four dependents, 11.5 for five, and 16.1 for six). More surprising is the observation that neither FTE doctorate nor FTE dissertation are longer for graduate students who are married or who have more dependents.

Indeed, the values for four or more dependents tend to be lower than for fewer dependents - FTE doctorate means not shown are 3.2 for four dependents, 3.4 for five, and 3.5 for six; FTE dissertation means are 1.4 for four dependents, 1.0 for five, and 1.8 for six. The increase in ELT with number of dependents is almost tautological; it simply takes time to accumulate dependents, regardless of any inclination to attend graduate school.

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Financial aid, as was the case with institutional transfer and field shift, significantly relates to elapsed time, but not generally to FTE doctorate and FTE dissertation. Most interesting is the trend, significant for psychology and sociology, for those with research grants to spend longer on their dissertations and on their doctoral program. To speculate, this may mean that students with research project grant support simply feel less pressure to complete their studies rapidly or that they have the resources to pursue more in-depth, time-consuming research.

Financial aid reported to be instrumental to the doctoral work was, not surprisingly, closely correlated with employment related to the dissertation topic. As shown in Table 2, such employment relates to shorter ELT but longer FTE dissertation.

Five measures were examined with respect to the nature of the dissertation. The one measure reported in Table 2, theoretical vs. experimental/empirical orientation, shows slightly shorter times for FTE dissertation and doctorate for the theoretician. Not shown are a minor lengthening of the FTE dissertation for collaborative as opposed to individual research, or essentially equivalent times for field vs. laboratory studies. Low student value placed on the dissertation produced only a 0.1 year shortening of FTE dissertation and doctorate. Beginning the dissertation research earlier tended to slightly lengthen FTE dissertation (significantly so in psychology), but to slightly shorten FTE doctorate. Zoologists and biochemists tended to begin the dissertation undertaking earlier (and these are also the fields with the low rates of field shifting from the bachelor's).

The last set of influences examined were career goals in seeking the

PhD. Teaching as a goal turned out not to relate to any of the time measures significantly. As shown in Table 2, those inclined to research tended to have shorter ELTs, but longer FTE doctorate and dissertation. Those oriented toward professional practice showed the converse pattern.

Path Analyses

Scanning the results of Table 2 suggests that the independent variables examined exert relatively little effect on FTE doctorate and only slightly more on FTE dissertation. More substantial are the shifts in the elapsed time from bachelors to PhD. Such a pattern reflects also from the path analyses performed.

The study strategy was to first examine the hypothesized models, then to modify those models to increase the amount of variance accounted for. The initial models for ELT, FTE doctorate, and FTE dissertation reflected the accumulation of postulated interactions among the variables and effects (Table 1), combined in a logical causal sequence. Path analyses were performed on the combined sample with field as a particular variable [13]. Correlations utilized were based on pairwise deletion of missing data, while the path coefficients were based on multiple regression using listwise deletion of missing data. This strategy provided more complete usage of the available data, and results were very similar to those for listwise deletion of correlation. The notion of path analysis is to decompose observed association (correlation) among variables based on hypothesized causal ordering [3, 10].

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Table 3 about here
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To summarize a considerable amount of data manipulation, examination of the initial three models showed them to be extremely poor in fitting the variables [13, That is, the variance in ELT, FTE doctorate, or FTE dissertation that was accounted for was small. In all three cases, therefore, it was desirable to modify and simplify the models to obtain the best possible fit. Figure 1 and Table 3 present the best fitting ELT model (by one measure, an adjusted R^2 of 0.21, indicating that 21% of the variance in ELT was accounted for). The model indicates that the number of dependents is the most significant influence on ELT with a direct causal path coefficient of 0.354. The other significant contributors are financial aid, institutional transfer, and field shift. Sex of student influences choice of field, employment, and number of dependents. Field, in turn, influences financial aid opportunities and likelihood of field shifting. Note that this model is much reduced from the original with only five of the variables relating to ELT directly. As shown in Table 3, the path model itself is quite simple with very little of the total covariance not modeled as direct influence. To assure that important information was not neglected, a number of calculations were performed. Stepwise regression yielded essentially the same results as the final model. Logarithmic transformation of the personal situation variable did not improve the final ELT model. In sum, generally shorter elapsed times are associated with students who have fewer dependents, receive federal fellowships and/or federal grants, do not shift fields, and pursue their doctorate at their undergraduate institution.

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Figure 1 about here

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The path models for FTE doctorate and FTE dissertation are not shown because they fail to account for substantial amounts of the variance (the best of the models tried, for FTE dissertation, yielded an adjusted R^2 of only 0.12). Nonetheless, the results can be summarized as supporting the implications of Table 2. The variables affecting FTE doctorate in the final model are:

theoretical vs. experimental/empirical type of dissertation, field, and research as a career goal. Field interacts with dissertation types, and research as a career goal associates with laboratory type dissertations. Grants instrumental to the doctorate associated with theoretical, field, and individual dissertation types. In sum, and with a great deal of caution, the implication is that FTE doctorate is shortened by choosing a theoretical dissertation for persons oriented to research, especially in the social sciences.

The final FTE dissertation model also needs to be interpreted with extreme caution. However, it also compliments the findings of Table 2. It shows professional practice as a career goal and experimental type dissertations reducing time to the dissertation, dissertation-related employment in the natural sciences lengthening it (see Table 2).

Conclusions

It is interesting to compare time from Wilson's sample of Southern universities in the 1950s to the present sample of 1969-70 PhDs. Caution is required in that phrasing of questions varies, and Wilson's categories corresponding to this study's biochemistry and electrical engineering are the broader ones of "other biosciences" and "engineering." Elapsed time from bachelor's to doctorate (ELT) and calendar time on the dissertation are the comparable measures (a measure also recorded in this study although FTE results are reported). For five of the fields, the present study finds ELT lower by an average 9%, with only engineering up by 5%. For four of the fields, the present findings on dissertation time show an average increase of 20%, with decreases of 17% in engineering and 12% in sociology. In sum, there appears somewhat of a trend toward more direct progression into a PhD program, yet more time then spent on the dissertation - a pattern more toward that of the natural sciences (Table 2).

This study of science-based fields indicates that time to the doctorate is quite idiosyncratic. Overall, while there are a number of significant relationships, what is most striking is that the variables examined account for relatively little of the variability in time. In particular, most of the factors postulated to influence time on the dissertation and on the doctorate proved ineffective. One of the interesting exceptions is that a career goal of professional practice, indicating that the research-oriented dissertation could be less relevent, did result in less time spent on the dissertation. In most instances examined, factors that increased the time for the dissertation carried through to evidence similar changes in the overall time to the doctorate. Two of the important disconfirmations are that financial aid and employment related to the dissertation did not serve to reduce the time involved in the dissertation and the doctorate; indeed, they increased time. Sex of the student also failed to associate with dissertation or doctorate time. Of course, this latter finding must be carefully considered with respect to field; our representation is among science-based fields with most of the women in psychology, biochemistry, and sociology (our sampling underrepresented women in the zoology field and there are very few in the 1969-70 cohort of electrical engineers and physicists).

Funding support tended to bear particularly on elapsed time from the bachelors to the doctorate. It was found that institutional transfers and field shift increased this time and that those in the physical sciences tended to have shorter ELTs. Increased numbers of dependents are also associated with longer ELTs. Financial aid in graduate school is associated with those who take less time from the bachelors to the doctorate; however, it is likely that this is not a causal relationship in the expected sense. Simply, there is more money available in the physical sciences which also tend to be the shortest in terms of elapsed time; financial aid, again, does not reduce the time on the dissertation and the doctorate per se.

What can one conclude? For one, there is indeed a considerable investment of time in the doctorate process. The dissertation requires on the order of a year in the social sciences and closer to two years in the physical sciences. The PhD programs demand nearly four years full-time equivalent and, on average, take eight calendar years from the bachelor's to complete. Individual variations are quite significant and are not neatly accounted for by the variables examined. This implies that individual planning and allocation of time, no less good fortune in the progression of doctorate studies, can make a tremendous difference. The dissertation is clearly a significant component of the doctorate program. Companion findings to this analysis [11] show that the PhDs surveyed, including those not oriented to research and even most of an informal sample of 25 ABDs (all but dissertation completed before leaving graduate school), basically favored continuation of present practices with their emphasis on the dissertation. There was little sentiment in favor of various changes to reduce the dissertation commitment and stress, including: several short research exercises in lieu of the dissertation, several short reports in a form like articles or alternative doctoral degrees that substitute other professional training for the dissertation period. In total, the present results do not suggest easy avenues to reduce the time commitment involved in obtaining a doctorate.

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TABLE 1

Summary of Hypotheses and Findings

Variable	Hypotheses* [Relevant Sources]	Findings
Field	"Hard" (physical science) FIELDS have shorter ELT, FTE doctorate, and FTE dissertation than do "softer" (social sciences) FIELDS [13, 8, 6]	Rejected
	*"Hard" FIELDS have shorter ELT than do "softer" (social sciences) FIELDS	Supported
Personal Situation	Students with three or more dependents have longer ELT, FTE doctorate, and FTE dissertation [13]	Rejected
	*Students with three or more dependents have longer ELT	Supported
Institutional Transfer	Shifting schools from bachelor's to doctoral program lengthens ELT [6]	Supported
Field Shift	The greater the extent of field shift, the longer the ELT [13, 4, 1]	Supported
	"Hard" FIELDS have less field shift than do the "softer" FIELDS [4]	Supported
Sex of Student	Women students have a longer ELT, FTE doctorate, and FTE dissertation than do men [13, 1, 5]	Rejected
	More women students have teaching as a career goal than do men [13, 1]	Rejected
	The sex of the student affects faculty and peer acceptance [2, 5]	Rejected
	Women students are more likely to be in a "softer" FIELD than in a "hard" FIELD	Supported
Financial Aid	Students receiving financial aid have shorter ELT, FTE doctorate, and FTE dissertation than those who do not [8, 4, 6]	Rejected
	*Students receiving financial aid have a shorter ELT than those who do not	Supported
	Financial aid is more instrumental for the "hard" science student than for the "softer" science student [13]	Supported
Employment	Students with employment related to the dissertation topic have shorter ELT and FTE doctorate than those who do not [7, 13]	Rejected
	*Students with employment related to the dissertation have longer FTE dissertation than those who do not	Supported
Dissertation	The lower the perceived student value of the dissertation, the shorter the FTE doctorate and FTE dissertation [13, 12]	Rejected
	The earlier the dissertation topic research is conducted, the shorter the FTE doctorate and FTE dissertation [13]	Rejected
	A dissertation that is theoretical, laboratory, and individual has a shorter FTE doctorate and FTE dissertation than one that is not.	Rejected
Career Goal	The career goal of professional practice helps shorten ELT, FTE doctorate, and FTE dissertation.	Rejected
	The career goal of teaching helps lengthen ELT and FTE doctorate [1, 13]	Rejected
	The career goal of research helps shorten ELT, FTE doctorate and FTE dissertation [13]	Rejected

[a]Hypotheses preceded by an asterisk are modified based on study results.

TABLE 2

Time as a Function of Various Factors

Factor	Elapsed Years from Bachelors to PhD (ELT)	Full time Equivalent Years to the PhD (FTE Doctorate)	Fulltime Equivalent Years on the Dissertation (FTE Dissertation)
Whole Sample	8.1 ± 4.1 (397)	3.7 ± 1.8 (625)	1.5 ± 1.0 (624)
Field	**	**	**
Physics	7.8 ± 2.9 (60)	4.3 ± 1.4 (94)	1.9 ± 1.2 (96)
Biochemistry	7.3 ± 4.6 (76)	4.0 ± 1.1 (116)	1.7 ± 0.7 (116)
Electrical Engineering	8.2 ± 3.6 (46)	3.1 ± 1.1 (103)	1.2 ± 0.7 (104)
Zoology	8.3 ± 3.9 (67)	3.8 ± 1.2 (121)	1.7 ± 0.9 (116)
Psychology	6.7 ± 3.4 (67)	3.6 ± 1.1 (101)	0.9 ± 0.5 (102)
Sociology	10.3 ± 4.9 (68)	3.5 ± 1.4 (90)	1.3 ± 0.9 (90)
Personal Situation			
--Marital Status in Year Prior to PhD			
Married	8.3 ± 4.2 (311)	3.7 ± 1.3 (484)	1.5 ± 1.1 (483)
Unmarried	7.2 ± 3.2 (66)	3.7 ± 1.2 (115)	1.5 ± 0.9 (113)
--N of dependents (not including self)	**		
1	6.4 ± 1.8 (95)	3.9 ± 1.2 (162)	1.5 ± 0.9 (160)
2	7.4 ± 3.7 (57)	3.8 ± 1.3 (101)	1.4 ± 1.1 (100)
3	8.7 ± 4.1 (85)	3.9 ± 1.5 (119)	1.6 ± 1.0 (123)
Institutional Transfer	**		
Undergraduate same as doctorate campus	6.9 ± 4.1 (68)	3.6 ± 1.2 (67)	1.4 ± 0.9 (67)
Undergraduate different from doctorate	8.4 ± 4.1 (328)	3.6 ± 1.3 (324)	1.4 ± 1.0 (323)
Field Shift	**, zoo		**, soc
Yes	9.4 ± 4.7 (92)	3.5 ± 1.1 (92)	1.2 ± 0.8 (93)
No	7.6 ± 3.7 (290)	3.6 ± 1.3 (285)	1.5 ± 0.8 (282)
Sex of Student			
Male	8.1 ± 4.0 (356)	3.7 ± 1.3 (561)	1.5 ± 0.9 (559)
Female	8.8 ± 4.8 (41)	3.8 ± 1.3 (64)	1.2 ± 0.9 (65)
Financial Aid			
--Federal Fellowship Instrumental	*, psy		PHY
Yes	7.4 ± 3.4 (223)	3.8 ± 1.2 (339)	1.4 ± 0.9 (333)
No	8.9 ± 4.2 (193)	3.6 ± 1.3 (284)	1.5 ± 1.0 (289)
--Federal Grant Instrumental	*, PSY		PSY, soc
Yes	7.4 ± 3.4 (223)	3.9 ± 1.2 (383)	1.6 ± 1.0 (383)
No	9.1 ± 4.7 (168)	3.5 ± 1.3 (135)	1.2 ± 0.9 (284)
Employment	**, BIO, psy		**
Related to dissertation	7.6 ± 3.8 (153)	3.7 ± 1.2 (206)	1.5 ± 1.0 (252)
Not related to dissertation	8.5 ± 4.6 (149)	3.6 ± 1.3 (250)	1.2 ± 0.8 (204)
Dissertation			
Theoretical	NA	3.3 ± 1.7 (103)	1.1 ± 1.5 (104)
Experimental/Empirical	NA	3.9 ± 1.6 (344)	1.6 ± 1.6 (345)
Career Goal			
--Research	**, soc	*	
Important	7.4 ± 3.4 (219)	3.8 ± 1.3 (370)	1.5 ± 1.0 (367)
Not Important	9.0 ± 4.6 (103)	3.5 ± 1.3 (141)	1.2 ± 0.8 (142)
--Professional Practice	psy	*	**
Important	8.1 ± 4.6 (110)	3.6 ± 1.2 (159)	1.1 ± 0.8 (162)
Not Important	7.6 ± 3.3 (175)	3.8 ± 1.3 (295)	1.6 ± 1.1 (293)

NOTE: Values are means ± standard deviations with number of respondents in parentheses; NA = not applicable.

*Significant by ANOVA F-test at the $p < .05$ level for all fields combined. Lower case field designations are significant at $p < .05$ for that field (means not shown).

**Significant by ANOVA, F-test at the $p < .01$ level for all fields combined. Upper case field designations are significant at $p < .01$ for that field (means not shown).

TABLE 3

Final Path Analysis - ELT Model

Bivariate Relationship (Influenced Variable/Influencing Variable)	Total Covariance (A)	Direct (B)	Indirect (C)	Total (D=B+C)	Noncausal (E=A-D)
ELT/Financial Aid (Fellowship)	.184	.184	0	.184	0
ELT/Financial Aid (Grant)	.207	.122	0	.122	.086
ELT/Personal Situation (Dependents)	.384	.354	0	.354	.030
ELT/Institutional Transfer	.133	.133	0	.184	0
ELT/Field Shift	.186	.132	0	.132	.054
Personal Situation (Dependents)/Sex of Student	-.220	-.220	0	-.220	0
Employment/Sex of Student	-.102	-.102	0	-.102	0
FIELD (of Study)/Sex of Student	-.001	-.001	0	-.001	0
Financial Aid (Grant)/FIELD	.317	.317	0	.317	0
Financial Aid (Fellowship)/FIELD	.205	.205	0	.205	0
Field Shift/FIELD	.201	.197	0	.197	.004

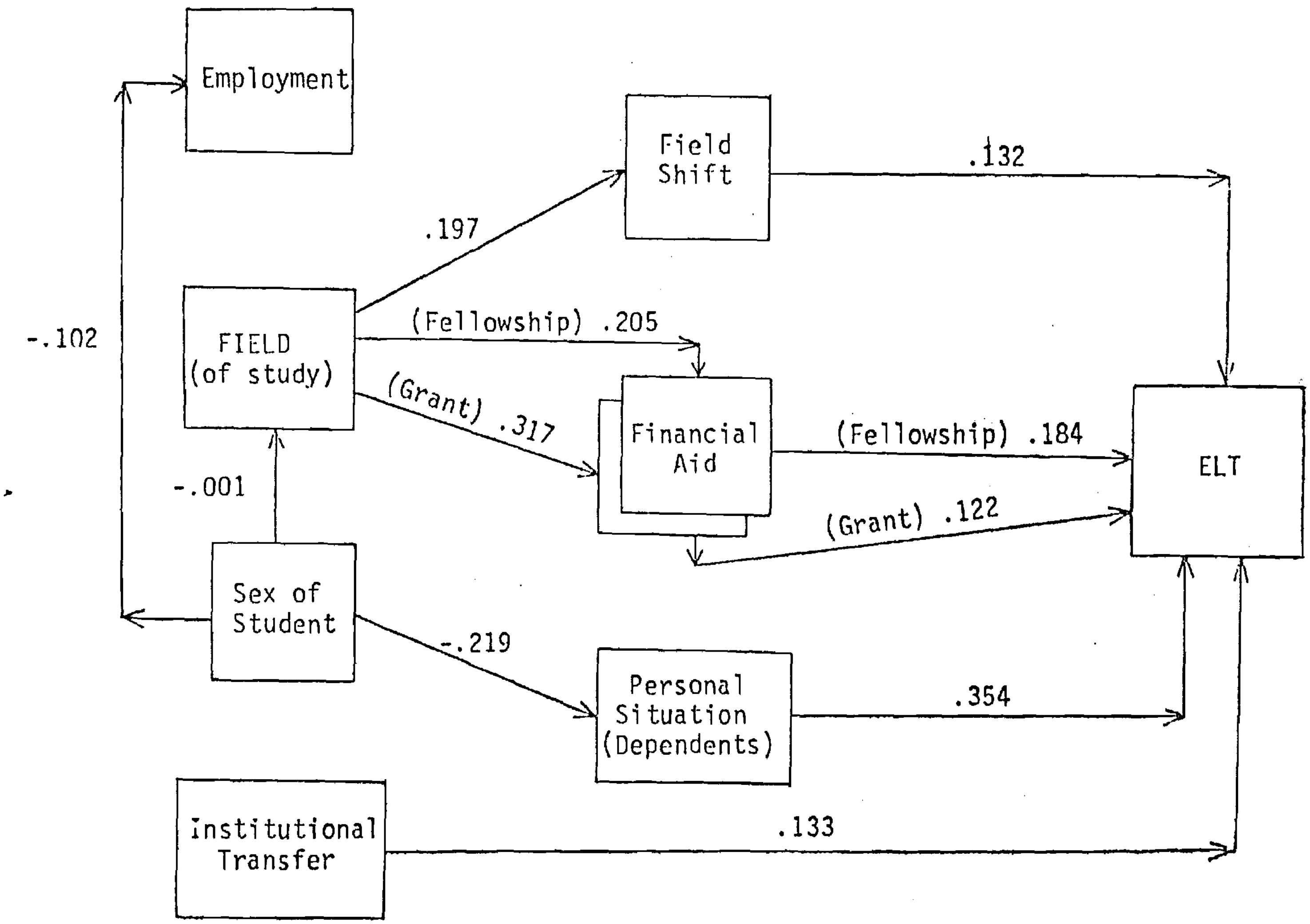

Figure 1. Final ELT Model

APPENDIX L

THE ABCs OF ABDs: AN INTERVIEW STUDY OF INCOMPLETE DOCTORATES

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Introduction

Doctoral candidates who never complete their dissertations, and therefore fail to earn the Ph.D., have not been a topic for much systematic study. Perhaps their failure to complete all degree requirements is a painful reminder to faculty and university administrators alike that their judgments of a student's capability and projected success have been faulty (see Horowitz, (2)). Such casualties of the graduate education system have always been with us, yet we know little about them, their perceptions of the graduate training experience, and above all, their assessments of their "failure" and subsequent career choices.

This paper intends to illuminate this shadowed side of graduate education: the "ABD" (all but dissertation). It is by no means a rigorous, statistical analysis of attrition in U.S. graduate schools. Rather, it is a narrative portrait, constructed from interviews with and anecdotes by a sample of ABDs who were Ph.D. candidates circa 1970. The study could best be considered a "collective biography" (4) of would-be doctoral scientists who consented to reflect in 1980 on their experiences in graduate school. Their recollections, however, are not all bitter. Indeed, the passage of time has, for many, confirmed their decision as the "right" one. Still, others yearn for what-might-have-been. The 25 people interviewed by telephone were remarkably candid in their self-appraisals and recounting of feelings now and then. They seemed surprised that anyone would be interested in them and overcame an initial hesitancy to talk once we made clear the reasons for our curiosity, that is, our interest in discovering the link between career patterns and specific graduate training experiences.

We believe that this paper begins to remove the mystery that has shrouded the careers of ABDs in science. Further, we think the assessments give new insights into the period of preparation for the scientific career, and especially into the range of emotion and commitment that graduate training brings to the surface and intensifies (1). Above all, we glimpse the humanity of our subjects and ask, "How do they differ from those who completed their dissertations?" Our tentative reply is, "They are not much different." What we have constructed here, then, is less a sociology of science than a sociology of work and careers, and some reminiscences about science. We present what we have learned in the hope of expanding the scope of study of careers, and focusing that study on a critical decision that is made by many, with serious personal and professional repercussions. For those who celebrate the traditional successes of science, this paper is an antidote, a reminder that smug approaches to technical manpower are a form of myopia that preserves ignorance. We are a little less ignorant having interviewed ABDs.

Locating and Interviewing ABDs

We experienced considerable difficulty in locating people who have completed all their doctoral work except the dissertation. There appears to be no national listing of such people. Individual universities maintain records of their graduate students in a variety of ways, but few keep systematic data on students who fail to complete degrees. Individual faculty members we contacted could rarely put us in touch with such students. In many cases our search was frustrated by concern for confidentiality.

Nevertheless, after persistent tracing of promising leads, we were able to locate 25 individuals who had completed all but their dissertations. Their fields of graduate training were psychology (n = 8), sociology (6), zoology (5), physics (3), electrical engineering (2), and biochemistry (1). Table 1 profiles the respondents on several dimensions. Perhaps surprisingly, none of them refused to be interviewed or expressed anger at the source who had given us their names. Most, in fact, said that they found the interview of some value in clarifying their feelings about not having completed their dissertations. Many asked for a copy of the results to learn how other ABDs had dealt with their experiences.

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Insert Table 1 about here
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The interviews were conducted by telephone, and lasted approximately 40 minutes. They were loosely structured around three major issues: reasons for leaving the doctoral program; possible impacts on life and career of not completing the Ph.D.; and assessments of the value of the Ph.D. and of possible changes in requirements for granting it.

Methodologically, the approach has two clear limitations. First, we were unable to sample randomly from any well-defined population, so the results are of limited generalizability. Second, the data collected were self-reports of emotionally loaded events of some years earlier, raising the danger that our respondents "rationally reconstructed" the events in question. What is presented below, then, is simply a summary account, often in the respondent's own words, of 25 ABDs reflecting on their experiences.

This study took place in conjunction with a large mail survey study of Ph.D.s in the same six fields (3), focusing on the graduate school experiences and later careers of scientists who completed their doctoral degrees around 1970. The findings from the survey provide a useful background against which to examine the results of the ABD interviews, and we shall refer to the Ph.D. study at several points.

Reasons for Leaving Doctoral Study

The reasons people described for leaving doctoral programs are listed in Table 1. In no case did an interviewee give only one reason for his or her failure to complete the dissertation. Often people began the interview by giving a single "stock" explanation, but as the interview progressed several issues emerged, and the first one mentioned was not necessarily the most significant. A few respondents admitted that they had never before given a great deal of thought to the experience as a whole.

The richness of the interviewees' recounting suggests that we report them by field. Due to the small n, we have aggregated the biological scientists' accounts; we doubt this has obscured detail.

Accounts by Interviewee Field of Study

1. Psychology

All the psychologists interviewed cited problems with their doctoral committees or advisors as a major reason for failing to complete their dissertations. Problems included dislike of the advisor expressed clearly and unequivocably as in, "He was a son of a bitch; if I wanted to ask him a question, he'd say 'make an appointment,' but he was the only person working in the area." This interviewee indicated, as did another from the same program, that the advisor's inaccessibility would have been surmountable had not the only helpful, cooperative, and encouraging person in the department died, leaving the graduate students entirely without faculty support. Asked why a new advisor was not chosen, both men said that would have been too awkward in terms of internal departmental policies.

Several interviewees described the losses of their major professors to death, firing, travel, or better jobs. These circumstances left them to be reassigned to other faculty members who either had no interest or competence in the students' fields, or who were already overburdened with students or other college responsibilities. As one interviewee put it, the only alternative advisor was "too old, too incompetent, and too uninterested in research." In each of these situations the problem was that the student received no guidance or encouragement from the advisor, and "lacked a catalyst." (This poses a strong contrast with the reports of 639 successful Ph.D.s, who, as a median, rated inspiration or stimulation by their supervisors at 3.84 on a scale from 1 = not at all to 5 = very much.) One person said that "one should always choose a topic in which someone on the committee has a vested interest in the area and [in] completion of the work."

Where there were no problems specifically with an advisor, there were often difficulties with the doctoral committee. Students whose topics required cooperation from more than one academic department seemed to find working with a committee particularly frustrating, and were sometimes caught in inter-departmental conflict. One student found that the engineering and psychology departments' mutual disdain made his committee, which included members of both, a battleground, where his work was a secondary concern. Another student who required the participation of both the psychology department and the school of theology described a similar experience. Methodological questions plagued the committee; the interviewee said that although he had a good relationship with the members of the committee, "There was no one on the committee capable of providing the kind of guidance needed, the kind of guidance which would reach the crux of the problem. The people were either psychologists or theologians and there was no one to bridge the two fields." Wherever there were problems either with the advisor or committee the interviewee reported receiving no help in resolving difficulties over interpreting negative data, reducing fragmentation of the data, or relating the data to the purpose of the research.

Beyond difficulties with committees, advisors, and research work, all the ABD psychologists mentioned additional reasons for leaving the doctoral program. Most common was the need for money. During their years as graduate students, most of the interviewees had families to support and were working while going to school; some finally decided to accept a job offer. One person described a common experience, "Out of the blue I was offered a job for $19,000, and since I'd just had to take a loan to pay my rent, I decided to take it."

The people who worked full-time while going to school had other difficulties. Almost inevitably the immediate demands of their paid employment became more pressing than the dissertation, and the dissertation was put off indefinitely. The two women interviewees both indicated that family pressures were great. In one case the husband finished his doctorate and took a job in another city, and the interviewee said that, at the time - 15 years ago - it neither occurred to her, nor did she receive encouragement, to stay the additional year needed to complete her Ph.D. She added that she was the only woman in her Ph.D. program and was told at the outset that she was not expected to finish. Had there been other women in the program, she believed, they could have pressed for more financial aid, and child care facilities, and supported one another in their work. The other woman interviewee said she was running a household, working full-time, and going to school. She finally "just ran out of steam and got tired." But, she added, had there been even one other woman in the program with whom to discuss problems, it would have been easier.

2. *Sociology*

The sociologists had quite different experiences from the psychologists. Whereas the psychologists' most consistent complaint was lack of support from advisors or committees, all but one of the sociologists had good relationships with their committees and spoke enthusiastically about their advisors. Even the one person whose problem was the inaccessibility of his advisor who "traveled all over God's creation," said that the advisor, when present, was helpful. Nonetheless, without the advisor's guidance, this interviewee lost interest in his dissertation topic. In addition, departmental jealousy and hostility toward his advisor was transferred to him.

Despite the fairly consistently laudatory comments by the sociologists about their advisors, many of them seem to have had difficulties with their research topics. Several said they had chosen topics that were too broad, and found themselves unable to narrow them. Topic changes were common. Three people expressed the desire to do "nontrivial" work, and so chose massive areas of research which they then found unmanageable. In each of these cases, the interviewee made it clear that he had been offered help by his advisor, but for personal reasons was unable to accept it. One said he was black and was at the time not able to feel comfortable with a white advisor. Another said he was not sure enough of his interests to be able to choose a specific topic. Another said he was an "intellectual loner, . . . neurotic about independence" and believed that accepting assistance was demeaning.

Financial need played a large part in several of the interviewees' decisions to leave their programs. As one man said, "I ran out of money, honey. Why does anyone quit?" Others said they were tired of living and trying to raise families on meager fellowships. When paying jobs were offered, they took them.

Once jobs were taken, the demands of those positions tended to make work on the dissertation difficult or impossible. Publication in journals was more necessary and rewarding than completion of the dissertation, and teaching obligations were numerous and time consuming. Nonetheless, three of the six sociologists interviewed have continued to work on their dissertations, and of these, one has, after a hiatus of six years, returned to graduate school to finish her work while on leave of absence from her job.

The sociologists were quick to attribute their failures to complete their degrees to their own personal problems. One interviewee described his experience as a function of personal problems he "did not know he had." He said he went to graduate school because it was expected of him and he found it dull and restrictive. He said he got "stage fright at undertaking such a large project [as his dissertation] and had an inability to see [himself] as a Ph.D." Basically, he felt he was just "too young to undertake a big, serious, self-motivating requirement." He reports that he has since changed, however, and now feels able to tackle the project. Reference was made by the two black interviewees to difficulty caused by institutional racism, self-consciousness, and a lack of peer support among black students.

3. Biosciences (Zoology/Biochemistry)

Among the 6 bioscientists interviewed, financial problems were cited most frequently (by 4 of the interviewees) as the major reason for leaving school before completing the dissertation. Interviewees spoke of the need for paying jobs by which to support their families; one said simply he was "sick of having no money."

Typically, however, financial problems alone were not sufficient to induce the bioscientists to leave their programs. Three of the six cited difficulties with their research topics as a contributing reason for leaving. Two of these were scooped by someone else publishing on their dissertation topic. This experience detracted from their interest in the original topic and was so demoralizing that they did not feel up to starting a new project.

Relationships with advisors and committees among the ABD bioscientists seem not to have been a common cause of the students leaving their Ph.D. program. Only one indicated that the relationship with his major professor was a factor in his failure to complete his dissertation. In this case the advisor had "no interest in students' work. He felt it was simply an obligation, but never encouraged students." Even this interviewee felt that he probably would have finished the dissertation had there not also been financial pressure on him to go to work. Three of the six bioscientists spoke highly of their major professors and dissertation committees. One went so far as to say that if his advisor could not keep him in the program, nothing could have. This interviewee said he felt he had exhausted the resources of his committee, although they had been very supportive. However, only a moment later he said, "on second thought, I had exhausted my own resources and was just tired."

Several other reasons appeared to contribute to the failure of the bioscientists to complete their dissertations. The prospect of difficulty in landing a satisfactory job after completion of the Ph.D. helped three of the interviewees decide to accept jobs before completion. A woman interviewee said she had just had a baby and was afraid that with a Ph.D. she would not be able to find a job which would have allowed her to work part-time. In each case the paid employment then demanded so much time and attention that there was no time to work on the dissertation research.

4. Physics

The three physicists interviewed gave varied reasons for failing to finish their dissertations. Financial pressures caused one to leave; when funding for the space program was cut, he lost his financial support. Although he had been urged to continue at his own expense, enjoyed his work tremendously, and had a good relationship with his committee, he could not afford a period without an income. He did indicate that had he been single, however, he would have found a way to finish the dissertation. Perhaps financial support arrangements should be more oriented to the needs of married students: 78% of our 1969-70 cohort of Ph.D.s were married at the time of their doctorate.

Family pressure of a different sort caused another of the ABD physicists to terminate his dissertation. He suddenly had to care for his ill mother. When his mother died, the year's leave of absence he had been permitted to take from his job had expired, and he was compelled to return to his duties. Back at his job, there was not sufficient time available to complete the dissertation. However, this interviewee plans to return to the dissertation as soon as he becomes eligible for another leave of absence.

The third physicist summed up his experience saying, "I really don't know what happened, and that's the truth. It was an interesting experience, and I haven't completely dealt with it yet." His difficulties seemed to be primarily emotional ones which manifested themselves in an inability to manage an enormous amount of data. This interviewee said the relationship with his committee chairman and thesis committee was very poor. They attempted to give guidance, but the interviewee refused it, because he had "a very rigorous belief about what a Ph.D. in physics was and [he] should be getting it on [his] own." Therefore, he remained aloof from both his colleagues and the faculty. He now realizes he would have had a far easier time had he seen that accepting help was not demeaning.

5. Electrical Engineers

The two electrical engineers interviewed came out of the same Ph.D. program and had the same advisor. Both described similar problems and similar experiences. The major difficulty faced by both was the lack of accessibility of their advisor, and lack of interest in them by the rest of the committee. There was no one there, in the words of one of the interviewees, "to encourage and give good ideas." Both attribute the indifference of the dissertation committees to their status as part-time students.

Both the electrical engineers eased from part-time work into full-time jobs, in the same area of employment. Once they began to work full-time their motivation to complete the dissertation declined. The demands of work made it increasingly difficult to find time to work on the dissertation and still meet their obligations to their families.

Impacts

The personal and professional consequences of leaving doctoral programs without completing dissertations varied significantly. Some interviewees felt that not having a Ph.D. had had severely deleterious effects on their careers. Others indicated that their careers had taken turns in unexpected but positive directions. The impact the interviewees felt appears related to their initial expectations and to the flexibility of their career markets. A common view was that not having a doctorate made initial job searches more difficult, but that once a job was begun, the calibre of their work spoke for itself. The major difficulty seemed to arise when they and their work were not known, and decisions (such as those on hiring or the funding of grant proposals) were made by strangers on the basis of credentials on paper. Even this difficulty, however, was often overcome as experience and reputation accumulated.

Several themes recur in the interviewees' discussions of the effects they have felt from not having completed a Ph.D. The most common perception is that not having a Ph.D. has limited career options. Most of the interviewees shared this view, although few expressed disappointment at the area of work in which they currently found themselves. Most had remained with a single employer since leaving graduate school. (Career mobility is a serious issue in scientific careers. Our sample of 1969-70 Ph.D.s showed 49% had changed areas of specialization, 21% even changing fields, in the decade since graduation. Few had been continuously employed in a single job over this time period.)

The feeling that career options for entry and advancement were limited was strongest among those who were, or wished to be, employed in academe. All fields, except the electrical engineers, observed a sense of constriction or foreclosure of university level opportunities. (Of the companion sample of Ph.D.s, academic employment ranged from a mean of 27% for electrical engineering through over 50% for physics, psychology, and biochemistry to 87% for sociology and zoology.) Some fields offer few real career alternatives the physicists, bioscientists, and sociologists, except one who was unemployed and one who was selling cars, were in academic jobs. All felt that the lack of a Ph.D. had adversely affected advancement and salary.

Job instability was a common experience for the sociologists, and one believed this instability had contributed to his divorce. Of the three bioscientists interviewed who teach at colleges, two say they have received subtle pressure to complete their Ph.D. in order to continue in their jobs. Another said he had had to teach at the high school level, rather than at the university level as he had wished, and therefore had suffered a lower salary, no research opportunities, and a "lower self-image." A woman biologist said that although she loves her job teaching part-time in a high school, she feels "feminist guilt" about her failure to finish her Ph.D. Nonetheless, she is sure she could get a good laboratory job, if she wished, and that she has many other career options.

Two of the three ABD physicists are now teaching at junior colleges. Both are happy, and both say that not having a Ph.D. has not adversely affected their salaries. One of these physicists, however, did say that he would like to become a division chairman but cannot be promoted to this position without a Ph.D. This same person indicated that having a Ph.D. and teaching at a junior college could be frustrating and lead to boredom, thereby adversely affect teaching quality. He said that members of the faculty who did have Ph.D.s "have to tie lead weights around their necks to keep teaching at the level of junior college students."

Of the ABDs now employed in academic work, the lack of a Ph.D. may have led to reduced involvement in research, and a greater concern for teaching and its attendant rewards. One ABD bioscientist at a university said he was pleased and proud of his career despite having been denied full professorship and having had to carry a heavy teaching load. He indicated that there have been advantages as well as drawbacks to his position. He said he has come to know "thousands of students, to care about teaching skills, [has] not been able to rest on his laurels and therefore make[s] a specific effort to keep current in the library and summer programs, so [he] can inspire students." One of the sociologists said that if she had had a Ph.D. when she accepted a paying job, she would not have taken the one she now has teaching in a school of social work. She said that although she is eager for the salary increase she will receive if she does complete her Ph.D., she loves her present work and would not consider changing jobs. Because the academic world so highly values the doctoral degree, all of the ABD sociologists seemed unusually pleased with the progress they had made in spite of the serious handicap of not having the Ph.D.

The two electrical engineers interviewed have felt no impact on their careers as a result of not having Ph.D.s. One said that before he left his Ph.D. program, he decided that having a Ph.D. would make little difference in salary or prestige. Although he realizes that teaching is closed to him, he never wished to teach, and therefore feels no loss at all. He believes that in industry a Ph.D. could be a liability because employers believe that people with Ph.D.s will be too theoretically oriented. The other electrical engineer claimed that in industry and especially in management, a Ph.D. is irrelevant to performance or promotion. Neither of the electrical engineers expressed any regret about not completing the doctoral degree.

Many of the psychologists in nonacademic jobs felt that the lack of a Ph.D. had had little impact on their career development. One interviewee pointed out that where he currently worked, there are "many other ABDs, and it's not a matter of concern in terms of advancement, salary, or respect." Another of the psychologists indicated that he has not experienced any difficulty in his work, which he enjoys and plans to continue, but that if he wished to change fields he might face some problems. Indeed, he stated with evident pride that although he is not currently a student anywhere and therefore will not submit it as such, his dissertation has been completed and accepted for publication.

Several of the psychologists expressed the view that lack of a Ph.D. is a hindrance primarily when one's work is not known. One interviewee said a Ph.D. "helps get a foot in the door." Common examples of where the lack of a Ph.D. is a liability arise in the need to attach resumes to grant proposals or when presenting credentials to nonprofessionals. One interviewee said there is an "aura of Ph.D.s among people who don't have them," but that people who do have them pay less attention because they know that a Ph.D. does not inherently indicate capability. Two of the ABD psychologists noted that not having a Ph.D. can at times be an advantage. In an applied area, "sometimes a Ph.D. is a detriment, especially working with engineers who believe Ph.D.s are in another world." In government work too, not having a Ph.D. can open doors. Excessive credentials can disqualify one for interesting though relatively low paid jobs from which one can advance in salary and position based on performance.

The two psychologists who felt most adverse effects of not having a Ph.D. were women. Both were employed at the same place as two of the male psychologists interviewed who said they had felt little impact. (This suggests that the women may have experienced sex discrimination as well as the disadvantages of not having a doctorate.) Both women indicated that although there is no official policy to this effect, they would have been promoted if they had had Ph.D.s. One of the women felt that with a Ph.D. she would have been seen by her colleagues as a "research scientist" rather than as a "glorified research assistant." The other woman psychologist also mentioned that with a Ph.D., her title would have been "research psychologist" instead of "associate research psychologist."

A common observation was that the ABDs would not be where they currently were, doing what they were doing, if they had completed their dissertations. This view of plans gone awry led in some cases to surprise and pleasure, and in some cases to regret. As one interviewee said, "who knows if I'd have arrived where I am by a different road."

Conclusions

We have spared few details in presenting the thoughts, and often the exact words, of 25 ABDs. We did this in the hope of revealing some distinctive human characteristics, and not just aggregated statistics on a category of scientists/engineers who do not possess the Ph.D. credential.

What emerges from our interviews is a fortitude concerning careers, toward reducing the gap between expectations and attainment, and an unmistakable pride about jobs well done. Regrets, of course, are a part of the ABD's story. By probing beyond those regrets we have found a wide array of perceptions about reasons for terminating graduate work. In some cases, not completing doctoral training is now seen as advantageous; in other cases, it is clear that having the degree is the only vehicle the ABD sees to career opportunity. In particular, the lack of a Ph.D. is a major barrier to a university career, and, therefore, most stifles those in fields with few substantial non-academic professional opportunities. Not too surprisingly, some ABDs are returning to graduate school, not to develop new skills, but to earn the "union card" that will allow a career to proceed as the scientist wishes.

Should the dissertation requirement be seriously altered? While we tallied several individual points in favor of various forms of relief, we did not find a groundswell of revolutionary fervor. By and large, the ABDs do not think badly of the dissertation that stands between them and the objective they once sought: the Ph.D. degree. Most feel that the dissertation should be retained for the Ph.D., though several suggested the value of other, though equally prestigious, degrees emphasizing training in areas such as teaching or clinical skills. Overall, however, this group of ABDs largely reflected the views of our sample of Ph.D. recipients. For all its defects and difficulties, the dissertation remains, for both groups, a valued capstone in the training of a researcher.

For those charged with the training of doctoral candidates we think the reminiscences and perceptions of ABDs should be enlightening. It may be that formal training is only as effective as the informal support system that faculty and peers provide, and in some programs, for some people, such support is never provided. Abuse of imbalances of power, such as between a student and his or her Ph.D. advisor is possible and warrants some form of protection and redress for the student.

What can be done to ease the pathway to the Ph.D. without detracting from it? The recurrent problem theme, across fields, for the ABDs was financial pressure. How much financial burden should a family (for few are single) endure to secure a Ph.D. for one of its members? In some fields the financial returns gainsay the effort: in the social sciences (no less the humanities) a Ph.D. offers negligible promise of a desirable job; in certain engineering and computer-oriented fields, professional demand is so great that there is again no financial sense in staying on for the Ph.D. Given our reports of the allure of a present job to a number of our ABDs, federal and other policy-makers would do well to think generously if they aim to increase the number of Ph.D.s in a given area. And without such compensations, academia will fall short in its quest for new faculty with Ph.D.s.

There may be an overall administrative lesson here too, but that lesson is not easily articulated. In general, graduate schools that hope that their candidates will finish their degrees must be sensitive to their students' individual needs, but there can be no single formula for being so. Perhaps future studies of ABDs can be part of the search, and can provide part of the formula.

Table 1. ABD Sample Profile (N = 25)

Sex: Male - 84%; Female - 16%

Age at Interview: Median - 39 years; IQR[a] - 37 to 46 years

Universities: 18 departments at 15 universities

Rated Quality of the Graduate Faculty[b] - Median - 2.8
IQR[a] - 2.1 to 4.0

Years Attended[c] - Median - 1967-1971
IQR[a] (1963-68) (1965-74)

Reasons for Leaving Doctoral Programs

1.	Financial difficulties	44%
2.	Poor working relationship with advisor and/or committee	44%
3.	Substantive problems with the dissertation research	36%
4.	Personal or emotional problems	36%
5.	Receipt of an attractive job offer	32%
6.	Interference of paid work with dissertation work	28%
7.	Family demands	24%
8.	Lack of peer support	20%
9.	Loss of interest in earning a Ph.D.	12%

Employment in 1979

1.	College	44%
2.	Contract Research Organization	32%
3.	Military Research Organization	8%
4.	High School	8%
5.	Selling Cars	4%
6.	Unemployed	4%

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[a]IQR stands for interquartile range, or the middle 50% of the responses.

[b]Ratings are scaled: distinguished = 5, strong = 4, good = 3, adequate = 2, marginal = 1. Charles Andersen of the American Council on Education kindly provided scores based on the peer study by K. D. Roose and C. J. Andersen, A Rating of Graduate Programs (Washington, D.C.: American Council on Education, 1970). These departments are a reasonable cross-section.

[c]Estimates are coarse as some enter with a master's degree; some depart, then return; etc.

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APPENDIX M

Chapter 3

MENTORS AND STUDENTS: SOCIAL HERITABILITY IN SCIENCE*

...the process of acquiring a grammar of scientific practice requires an engagement in research on the model of some skillful practitioner in whose person there is incarnated both the general culture of science and particular traditions within that culture. One can no more discover the culture of scientific research from its written results than one can construct a Stradivarius from measurements of an original.

Michael Overington (1977:145)

The strategy of research is never blind trial and error, but is governed by the intelligent appreciation of possibilities and solubilities. To ask 'how much is to be believed?' is to invite oneself inside the scientific process...

John Ziman (1978:141)

He's like a very demanding father...His expectations for my success transcend even my own. Everyone who's recruited is told, 'This is the best damn lab in the world, doing the most exciting stuff in the world. If you're not famous by the time you leave here, it will be my fault.'

(A research fellow in Gerald Wasserburg's "Lunatic Asylum" at Cal Tech, quoted in Ward, 1980:49)

What does one learn in graduate school? The glib response, proferred more than a decade ago by Harriet Zuckerman (1970:244) is "what matters." What matters takes place in a mentor-student, or master-apprentice, relationship. What is embodied by this relationship is the attribution of student competence (if not talent) and the legitimation of reciprocal professional roles. "What matters" is the topic of this chapter. In it, I will advance the notion of "social heritability" in science and distinguish the kinds of knowledge learned in the mentor-student relationship. Then I will examine how these kinds of knowledge are used as resources or tools to fashion and display the scientist's craft-cum-style.

*To appear in D. E. Chubin, Social Trappings of Knowledge.

My conceptual analysis will preface a review of scientific careers, particularly the cultural successes symbolized by the Nobel prize as putatively representative of scientific progress. The interpersonal processes which enable knowledge claims to be produced, negotiated, and (sometimes) acclaimed, I will argue, is socially structured, indeed inherited, through the mentor-student relation. What matters in this relation is not the transmission of intellectual or technical craft skills per se, but the student's acculturation to certain social and epistemological precepts which stylizes the expression of craft skills. As certain expressions (claims) are recognized as successful approximations of truth, careers evolve to confirm the judgment of mentors and warrant the acclaim of their students as "genealogical partners" in an otherwise apparently amorphous pool of academic orphans, mutants, and clones.[1] Thus, to explain social heritability in science is not to tabulate "successes," but to reconstruct a social ledger of debits and credits to individuals in organizations. It is within prevailing community and cultural standards that careers unfold to reveal the timeless character of science (in inquiry and pedagogy) as craft.

SCIENCE AS CRAFT

A veritable treatise on science as craft work is found in Ravetz (1971: (Chapter 3). His introduction to the subject states that:

> without an appreciation of the craft character of scientific work there is no possibility of resolving the paradox of the radical difference between the subjective, intensely personal activity of creative science and the objective, impersonal knowledge which results from it (Ravetz, 1971:75).

> Craftsman's work cannot be learned from books, but from experience, rived from a teacher by precept and imitation, and supplemented by the personal experience of the operator himself...(Ravetz, 1971:140).

Two central ideas emerge from Ravetz's perceptive inductions--the intuitive nature of the craft-scientist's[2] knowledge and the way in which that knowledge is imparted to the graduate student-apprentice. The scientist's knowledge is of two types--technical and tacit--whose properties require extensive description.

Knowledge: Technical and Tacit

As Ravetz (1971:75) acknowledges, much of his conceptualization of science as craft work derives from Polanyi's (1958) Personal Knowledge. The keynote is that the scientist must develop a personal, tacit knowledge of his/her objects and what can be done with them in order to produce good work. For "by experience, his hands and eyes have taught themselves. It is this subtle interaction of the craftsman with his material... which gives handicraft productions their special charm" (Ravetz, 1971: 75-76).

If the "special charm" of a scientist's research results from an intuitive or tacit sense of it, then the pedagogy by which that sense is acquired is far more subtle than we have been led to believe. Kuhn's (1963: 344-345) skeptical view of science textbooks is instructive here for "textbooks do not describe the sorts of problems that the professional may be asked to solve... rather, these books exhibit concrete problem solutions that the profession has come to accept...(N)othing could be better calculated to produce 'mental sets' or Einstellungen." Kuhn (1977b:306) later emphasizes the student's ability to see "group-licensed resemblances" between apparently disparate problems and to acquire "an arsenal of exemplars" therefrom.

Although there is nothing tacit about an "arsenal of examplars," the process of its inculcation surely depends on the student's sense or intuition about its relevance, if not indispensability and "revealed" truth.

What was discussed in Chapter 1 as a stratification of experience is embedded in the technical knowledge of a science. Once accepted by the student,[3] this knowledge--first articulated in revisionist textbook histories, next in the serial literature to which the student is exposed--becomes a resource that reinforces the legitimacy or reality of the science. The science "comes alive" only after a commitment to it as one's craft has been made (see Clignet, 1979: 403). With such an emotional investment, technical content takes on a rhetorical function. For the literature, and scientific discourse in general, is a set of arguments or assertions about material objects and their connection to particular cognitive manipulations which yield a structure of inferences (Ravetz, 1971: 120-121).

Overington (1977), for example, takes the rhetorical function one step further by substituting the concept of "audience" for that of the "scientific community." His analysis of "science as rhetoric" features a four-stage process involving "speaker," "situation," "audience," and "argument." Most relevant to the present focus is the view that "the education of young scientists transforms them into licensed speakers about matters that concern their communities." They "publish arguments which offer plausible reasons for judging the conclusions of these persuasions to be valid." Only then do "scientific audiences provide authoritative judgment on the status of these arguments as scientific knowledge" (Overington, 1977:154).

Because any scientific description will never perfectly fit the objects of the inquiry at hand, the student must believe, take as axiomatic, or rationalize the connections among assertion, manipulation, and inference. The context for belief is the mentor-student relationship. Here the connections are perceived as "technical knowledge," the literature as a persuasive articulation that others believe it as well. What is important to recognize is that once scientists are persuaded, they develop the capacity to persuade. In this sense, the rhetoric of technical knowledge is itself a resource to be manipulated, indeed exploited, in one's subsequent (post-Ph.D.) craftwork. The ramifications of such rhetorical exploitation are explored below.

For now, we have distinguished two categories of knowledge, tacit and technical. To posit the existence and transmission of each is to underscore the social character of the mentor-student relationship. And while our analysis is "interpretive" in nature (Law, 1974), a sketch of the "normative" properties of the relationship will illustrate why the acculturation experience is so decisive in establishing one's cognitive style and requisite intuitions for the negotiation of "essential tensions" (Kuhn, 1963) within the research career.

Scientific Norms: Social and Cognitive

The contentious (and relentless) debate on the institutional norms of science or so-called scientific ethos (Merton, 1942) is germane in several ways to our discussion of knowledge transmission. As freshly reviewed by Stehr (1978:173-174), the norms (quoting Merton) are an

> affectively toned complex of values and norms which is held to be binding on the man of science. The norms are expressed in the form of prescriptions, proscriptions, preferences and permissions! They are legitimized in terms of institutional values. These imperatives, transmitted by precept and example and reinforced by sanctions are in varying degrees internalized by the scientist....Although the ethos of science has not been codified, it can be inferred...as expressed in use and wont, in countless writings on the scientific spirit and in moral indignation directed toward contraventions of the ethos (emphasis added).

What Merton has stipulated is a universal process by which scientists learn to behave and expect others to behave "scientifically." Critics have assailed this supposed learning as unduly "rational," "positivistic," "mythical," and "ideal" (the notable authors being Barnes and Dolby, 1970; King, 1971; Mitroff, 1974a).[4] Among others who dissent from the ethos, Kuhn (1977b:318) admits that the term "paradigm" entered The Structure of Scientific Revolutions because he "could not, when examining the membership of a scientific community, retrieve enough shared rules to account for the group's unproblematic conduct of research. Shared examples of successful practice could...provide what the group lacked in rules."[5]

Kuhn's observation, later amplified by Mulkay (1969), was that the technical norms of paradigms, i.e., the cognitive content of research traditions and problems, frame the behavior of scientists. The ethos, in short, is acquired in an intellectual (and political) climate and activated as knowledge claims are made and negotiated. Apart from this climate or context, the ethos carries no moral imperative.

What critics have hitherto failed to appreciate is that the social norms are chiefly acquired as tacit knowledge; they are taught by example and intonation, not as codes of conduct which every scientist qua scientist should (must!) obey. Thus, the scientific ethos is transmitted along with epistemology as an approach to one's craft, as an intuition which structures expectations of both how one's objects and peers ought to behave under specified conditions. What Merton (1942) originally said still holds today: "the ethos of science has not been codified."

What, then, is a result of the (largely non-discursive) pedagogy of mentors? One result--labeled "ambivalence" and "counternorms" (Merton, 1965; Mitroff, 1974b--has underscored the gulf between "professed" and "statistical" norms. But the differences between (i) principle and practice, (ii) what scientists do and say they do, (iii) what scientists think about and what they articulate help to define some continua on which scientists are distributed. The data, however, have been less definitive than the theoretical notions that prompted their search. Whereas criticisms have dwelled on (i) and (ii) above, only in the most current wave of work on the ethos has attention focused--fleetingly--on (iii).

The difference between technical and tacit knowledge, as conceptualized above, parallels the difference between the cognitive processing of craft-objects and public, particularly written, statements regarding their character and meaning. The paradox is that <u>what is tacitly learned must be rhetorically expressed</u>. An expression is formatted and re-formatted to convince various audiences--ranging from one's community of peer specialists to a lay public--of its validity. Mulkay (1976a:654) calls these audience-specific expressions "vocabularies of justification." Learning such expressions is a normative undertaking that governs "the articulation of an occupational ideology" (Chubin and Studer, 1978:66). These "rhetorical" norms, then, occupy a central place in the mentor's agenda. In the course of exemplifying the technical skills essential for scientific craft work, the mentor equips the student with a set of epistemological clues (Overington, 1977:155-156) that are expressed in normative and counternormative behavior. There is slippage, however, in what social analysts have posited in the following ideal-types.

1. Universalism-Particularism[6]: Students realize that not all work is created equal and that work produced by scientists, labs, and universities linked to the mentor is deemed of greatest value; this work is read first and scrutinized with more care than that produced by unknowns (Merton, 1968; Haberer, 1969; Turner and Chubin, 1976).

2. Communism-Solitariness: Research results are publicly shared on the producer's timetable. Hence, secrecy is justified and limited distribution of preprints, e.g., sent only to those peers identified by the mentor, is routine practice (Gaston, 1973; Edge and Mulkay, 1976).

3. Disinterestedness-Interestedness: Claiming knowledge is a process whereby power is exercised in and gained from various communities (approbative audiences). This is largely self-serving so that a scientist's rhetoric is neither indicative of his/her motivations nor a faithful reconstruction of his cognitive processing of a research problem (Bourdieu, 1975; Nelkin, 1975b; Stehr and Simmons, 1979).[7]

4. Organized Skepticism-Organized Dogmatism: This is the obverse of universalism-particularism, i.e., few contemporary scientists are to be believed. Those who are identified by the mentor as a source of significant work are not to be doubted. Further, one's convictions about the above and one's own formulation are not to waver in the face of contrary evidence (Mitroff, 1974b; Collins and Cox, 1977; Dolby, 1979).

The hypotheses subsumed under these four normative pairings all involve the student-scientists' "attribution of meaning to complex sets of clues generated by scientists' actions on the physical world...(Such) attribution of technical meaning is always inextricably bound up with those processes of social attributes of participants" (Mulkay, 1979a:65).

In short, the scientific ethos becomes a resource in the scientist's "technical baggage" via the mentor's presentation of it as manifestly "intellectual." No differentiation of epistemological, rhetorical, or social considerations is ever explicitly made. Rather, these craft skills are "exhibited" and students come to adopt them as their own.[8]

Thus the scientist's craft is a curious blend of norms "absorbed" through the research process. As Ravetz (1971:103) observes,

> [T]he scientist's craft also includes the formation of problems, the adoption of correct strategies for the different stages of the evolution of a problem, and the interpretation of general criteria of adequacy and value in particular situations... distinguish original scientific work from the routine production of bits of information, have no standardized, elementary versions to which simple, explicit precepts can apply. Hence most of the body of methods governing this work is completely tacit, learned entirely by imitation and experience, perhaps without any awareness that something is being learned rather than 'common sense' being applied. Since this sort of knowledge is so different in character from that embodied in the published results, and is transmitted through a different channel, it is not capable of the same universality of diffusion, nor of the same closeness of control of quality.

If we admit that scientific pedagogy does not proceed in a social vacuum, then its "common sensical" character is appealing. We believe it! We feel it. Recalling our own training, many will privately acknowledge the subtlety of "sensing" or "expecting" what our mentors "wanted" from the objects they manipulated and the colleagues with whom they interacted. What we have termed above--groping for the "correct" his actions and ideas then it is not too great a step to consider science as an ordered phenomenon which is connected to its conditions of production. The structure of scientific production here includes the day-to-day organization of work, the intellectual background to research and processes of recruitment, training and elite formation" (Whitley, 1977:23). While "processes or recruitment," preceded by perceptions that a department or institution is populated with elite minds pursuing novel research, lure students (and faculty) to certain university environments,[12] my present concern is what happens once these personnel arrive. Whitley,(1977;1978) maintains that what happens depends on the nature of the scientific objects under scrutiny.

The implication of his argument is that pedagogical craft work should be highly variable across graduate school (i.e., department and laboratory) contexts. Aside from differences in technical content, physics and political science, for example, will be presented to students in highly stylized fashions. The style is the mentor's; it is readily "imitable" and it reflects his/her style of training, vagaries of research experience, and current preoccupations with local organizational emphases and intellectual themes. Thus, learning to be an experimental high energy physicist will hardly resemble the process by which comparative government is taught. Becoming an experimental high energy physicists at Cornell as opposed to Stanford, however, is quite another comparison. Each of these institutions enjoys resources (e.g., sophisticated accelerators and formidable federal funding), international reputations, and a division of labor featuring numerous faculty, postdoctoral research associates, technicians, and predoctoral students. One's apprenticeship will be shaped not only by the team approach to research,[13] but by the mentor's style as well. Thus, in a sense, research supervision epitomizes the integration of two primary scientific roles -- teaching and research;[14] In another sense, however, such supervision epitomizes, in Whitley's (1977:41) words, the "increasing routinization of doctoral work."[15]

The crux of these arguments is that the scientist must first make his/her craft plausible (by demonstration) to the student; next, through imitation and manipulation, the student develops a familiarity with the craft; eventually through experience and independent thought, the craft becomes entirely natural. It is here that technical knowledge "feels right," subject to tacit processes of anticipating pitfalls and expecting certain outcomes. The transition from "plausible" to "familiar" to "natural," however, is at once conservative and creative.

The conservative aspect is the "routinization" noted above. Succinctly put, "the imaginative work of perceiving new phenomena and setting new problems will tend to be done in terms of what is already intuitively known" (Ravetz, 1971:141). This aspect may be likened further to the absorption of technical knowledge. As it becomes familiar and natural to the neophyte scientist, it also becomes a tacit resource for identifying and exploiting new problems. Yet this knowledge constricts the breadth of vision, i.e., conceptualization of research, while extending the scientist's depth.

The creative aspect of the transition resides in the style by which the research is executed. Just as the mentor's organizational setting (e.g., facilities and cosmopolitan reputation) lured the student, so did the "revelation of craft" gradually transform the plausibility of technical expertise into a familiarity. The rhetoric invoked by mentors calls students to the scientific craft. Once the knowledge of craft becomes a "natural sense," the rhetoric centered on the manipulation of scientific objects _itself_ becomes a resource. The use of rhetoric is _the_ creative aspect of research; it is idiosyncratic, stylized, and a discriminating factor in the proposal, negotiation, and ultimate recognition of claims to knowledge (within or across scientific audiences) as "novel" or "innovative."

Certain environments are known to be conducive to such creative activity. For example, whether within traditional units such as departments or in campus-wide institutes, centers, and programs, universities are touted as the fount of original thought and breeding-ground for critical thinkers.[16] Once again, a stereotype has outlived its usefulness. For universities can be seen as mundane bureaucracies ill-equipped to stimulate and reward originality and criticism (see Blau,1973; Rossini et al., 1981). The system serves those mundane tendencies, as we have above, by routinizing the reproduction of scientific manpower. Is it the persevering conformist who survives the rites of passage to certification as a doctor of philosophy in X with a concentration in X_1? Are the mavericks, renegades, and other intellectual "deviants" systematically cooled out, or do they fall victim to their own disillusionment (Horowitz, 1968b)?

Who remains to receive degrees and carry on or challenge research traditions? Do mentors clone themselves or do their students evolve into independent thinkers? Precious few answers to these queries can be found in the literature. Those that do emerge are deterministic or reductionist, i.e., tied to structures and processes which are at root highly variable and context-specific (e.g., Gustin, 1973). The "answer" toward which I have been driving, however, is predicated on idiosyncratic factors --personality and individual biography.

The answer, of course, is no answer at all, but still another (social-psychological) dimension of scientific work and an outgrowth of the learning-knowing-sensing that accrues from the mentor-student relation-- "cognitive-style."

Cognitive Style as Craft

The mapping of individual differences in biography and personality onto scientists' career choices, e.g., discipline and employment sector, has furnished only a modicum of guidance in identifying and analyzing cognitive style.[17] What has been diagnostic, though not used "intergenerationally" as a means of associating mentors and students, is summarized in Mitroff and Kilmann (1978: Chapter 2). First, what I have called "cognitive style" embodies both epistemology and *Weltanschauung*; it combines intellectual and emotional temperament. One's style is something one *feels*, not merely thinks; it is the personal art of one's science.

Second, scientists can nevertheless be classified as to their cognitive style. Hudson (1970), for example, distinguishes "convergers" from "divergers." The former abound in the natural sciences, the latter in the humanities and social sciences. Both the converger and diverger styles, say Mitroff and Kilmann (1978: 13), are creative; but each has a "blind spot" so that together a scientist of one type complements, and compensates for, the style of the other. Whereas convergers seek the single right answer, divergers relish the creation of ambiguity or the invention of many possible right answers.

Speculation as to the underlying causes of cognitive style must center on individual biography and personality. But we can be more specific. For the idiosyncrasies of one's career are uniquely inter-individual, i.e., interpersonal, as well. As a model, a mentor's style will be prescriptive; thus, we might hypothesize, following Whitley and Kuhn, a congruence between a mentor's style and that of his students.[18] But role models can, of course, be either positive or negative. A converger mentor could unwittingly, and perhaps to his dismay, reinforce a diverger style in a student. The more likely outcome we would predict, however, is that one's stylistic predilections will be patterned after those of a powerful, indeed omnipotent, mentor (see French and Raven, 1959). For style is not merely an epistemological or intellectual choice; it is a rewarded activity. Lack of conformity, in the mentor's eyes, can become more than an innocent transgression of curiosity; it can become a mark of incompetence, a flaw in one's armamentarium of technical knowledge (i.e., a violation of a cognitive norm), or a rhetorical deficiency (i.e., the inability of the student to convince the mentor of his competence or professional facility).

Clearly, the interaction between mentor and student, and comparatively speaking, between a mentor and <u>several</u> students, is crucial. Have the students been acculturated? Do they perceive scientific objects in the "proper" way? Has the mentor's craft (intuition and style) been internalized? Answers to the queries are constrained by the social inequality inherent in the mentor-student relationship.

Fortunately, some headway has been made with cognitive style, albeit the contextual analysis alluded to above has yet to be performed. The headway is due chiefly to Gordon and Morse (1969). Using the Remote Associates Test (RAT) that measures one's ability to solve a structured problem, Gordon and Morse reasoned that creativity in science also demands recognition of new problems from disparate bits of information. They call this ability "high differentiation," e.g., of figure from ground or signal from noise. Combining these creative dimensions, Gordon and Morse derived a typology of scientific problem-solving styles which Mitroff and Kilmann (1978: 18-19) summarize as follows:

> Integrators supposedly possess both the ability to recognize previously unperceived problems (high differentiation) and the technical skills to solve problems once they are recognized (High RAT). Problem Solvers (High RAT) in contrast, possess the ability to solve already formulated problems but lack the ability to recognize new problems (low differentiation). Problem Recognizers are just the reverse of Problem Solvers. Technicians possess neither the ability to recognize new problems nor to solve any but the most standardized problem. Thus, Gordon and Morse postulated that Integrators would be the most innovative, Technicians the least; in addition, Integrators would require the least supervision, Technicians the most (italics added).

In general, tests of the Gordon-Morse typology on samples of industrial scientists have borne out its predictions. Similar tests of mentor-student samples would no doubt prove informative, not just in terms of the cognitive distribution of each, but moreover in terms of their joint distribution, i.e., the distribution of stylistic compatibility among mentor-student dyads. In the absence of such data, we can nevertheless employ the conceptual tools which cognitive style researchers have developed in linking scientists' craft behavior and career paths to the prevailing intellectual climate in their respective research communities and home organizations.

Consider for example, Kuhn's discussion of "the essential tension." In it, he (Kuhn, 1963:351-352) undertakes a social psychological analysis par excellence, noting that the scientist must be, at least potentially, an innovator, possessing mental flexibility, while being a firm traditionalist or convergent thinker. How, then, can these two superficially discordant modes of problem solving be reconciled both within the individual and within the group? And if the real innovators in science are the Integrators and Problem Recognizers, are they rare breeds? Unless innovators are "born" and not "made," the Kuhnian search for the conditions under which innovation emerges--and is nurtured as a style--must continue. For I agree that "the productive scientist[19] must be a traditionalist who enjoys playing intricate games by preestablished rules in order to be a successful innovator who discovers new rules and new pieces with which to play them" (Kuhn, 1963:352).

From a historical perspective, individual innovation may be restated as Ravetz's (1971:127) aphorism: "The forward progress of science must necessarily be accomplished largely by way of detours." One who takes detours is taking risks, departing from prescribed paths, venturing into alien territory, choosing for study "exotic" or unorthodox problems. The scientist who pursues such a course is indeed an exception stylistically and statistically.[20] The rule is continuity of interests within a research tradition. In short, Problem Solver is the dominant style. And it is at one's professional origins--graduate school--where style, if not fixed for all time, comes to embody a negotiation of mentor's and student's predilections and personality. If stylistic discontinuities between mentor and student appear subsequently in the latter's career, we may construe them as repudiation of the mentor's influence or, alternatively, as perhaps the student's intellectual "coming of age." Such maturation doubtless occurs on no fixed schedule and with varied intensity. What we now must ask is why does it occur at all and among whom? How do we know it occurs and, above all, what does it mean?

If what we have characterized as cognitive style effectively derives from one's interaction with a mentor in a socially structured, tellectual relationship, then what little we know of scientific careers could be recast as a social-psychological--public and private--negotiation of epistemologies and norms. Without reccourse to biographical idiosyncrasy and social (organizational) attributes, career patterns become a temporal ordering of roles and behaviors instead of a contextual analysis of knowledge creation and manipulation.[21] To participate in this process of claim, negotiation, and recognition, the scientist must possess a sense of "what matters"--a craft and a style for expressing it. This conceptualization of the mentor-student relationship has indicated how very complex, and subtle, scientific craft work is. In the second half of this chapter, I seek to specify further how the claim-negotiation-recognition process occurs, what the cognitive style correlates of this knowledge process are, and how career success --in the extreme--both typifies and distorts the intellectual (e.g., pedagogical) relationships established during the graduate training experience.

HERITABILITY AND HUBRIS IN SCIENCE

Just as the kinship system regulates the transmission of the cultural and genetic heritage of a society (White, 1963; Levi-Strauss, 1969), the mentor-student relationship assures continuity--perhaps to the detriment of science, as the foregoing analysis has suggested--in the acculturation process.[22] The importance of mentorship for studying the structure of science has been demonstrated by historians (e.g., Boring and Boring, 1948; Rothschuh, 1973) and social scientists (Ben-David and Collins, 1966; Fischer, 1967; Mullins, 1972; Wesley, 1965). Utilizing a genealogical framework, they have traced the influence of great scientists, albeit in a limited fashion,[23] within certain disciplines and sub- or cross-disciplinary specialties.

Adoption of a genealogical framework, however, accords prime significance to one's professional "birth" into a scientific career and the mentor's role in that process. The focus is still the <u>structural</u> link between mentor M and students S, T,...,Z. The whole craft process is an inference as to what must have transpired between one's origins in graduate school, e.g., exposure to mentor M, and one's eventual career successes. In other words, the social-psychological processes of craft acculturation are presumed to be effective in a vague, undifferentiated way. But the fulfillment of mentors' expectations neither vindicates nor explicates those processes. Nor does a genealogy per se. Such a structural representation is a first step toward exploring the social heritability hypothesis. It underscores the suspicion that technical/tacit knowledge is a demographic phenomenon, too. Ph.D.s are "made," but--metaphorically at least (see Zuckerman, 1977, and below)--they are "born." The site of their birth--the doctoral institution and specific (departmental) organization within it--together with their "progenitors" determine in a "genetic" or structural way, their initial career path.

One might hypothesize that the circumstances of one's birth (or acculturation) "imprints" intellectual tendencies that are manifested later in one's adult career as "migration" to new problems, the embrace of new roles, etc. Status mobility, e.g., to a higher rank or a more prestigious institution, is only one measure of such demographic change.[24] What warrants attention is the content of one's cognitive style and the resourcefulness of one's craft manipulations, i.e., one's "cognitive mobility." Just as Whitley (1977) warned above of a "free agency" mentality, I detect in the scientific career literature a "hubris" mentality (see Thomas, 1978, for a similar application of the word) that reeks of both "inheritance" and self-congratulation. Its claim is that the triumphs of a career justify all that preceded them, that further, all were earned, and all signify "the truth." But in science, "truth" is an ephemeral commodity; it eludes the best and worst of minds. Hence, our knowledge is claimed, measured against a shifting community standard (recall the cognitive/social norms), and regarded as only tentatively better than other claims. But how are claims so adjudged? And what is inherited in the process?

To address these questions, I turn first to a sample of extraordinary scientists, a scientific elite: Nobel laureates. To read Zuckerman (1977) and others (for a bibliography of studies on the Nobel prize, see Vlachy, 1979), one is left with the nagging impression that we know "the most about the least" number of scientists—living and deceased. After testing the social heritability hypothesis with these data, we will consider a more typical sample of doctorate sicentists recently surveyed a decade after their degrees were conferred. Upon comparing the insights derived from these studies, our residual ignorance and especially the fallacies regarding the mentor-student relationship as a source of the essential tensions which motivate individual careers, should be evident.

Generalizing the Elite Experience: Fallacies and Realities

"Are great scientists great because their speculations have somehow proved fruitful or because they were willing to risk bold speculations in the face of extreme criticism from their peers" (Mitroff and Kilmann, 1978:62)? With this question lodged squarely in mind, we can proceed to the fascination afforded by "great scientists." How do they become so recognized and to what do they and others attribute their greatness?

Perhaps the supreme symbol of greatness, both within scientific communities and without, is the Nobel Prize. The legacy of Alfred Nobel stands "as a brooding omnipresence over contemporary science" (Zuckerman, 1978a:420). Since 1901, the Prize has been awarded in physics, chemistry, and physiology-medicine; in 1969, a prize in economics was added. Though coveted cross-culturally, and (through 1976) bestowed upon 313 scientists, "it is not self-evident why the Nobel Prize should be so widely visible and confer so much prestige. There are, after all, older prizes in science and richer ones, as well as some of similarly international cast" (Zuckerman, 1978a: 420).

Zuckerman's (1977) masterful appraisal of and postscription (1978a) on this "scientific (ultra-) elite" highlights the capricious as well as the systematic aspects of the selection criteria and process. For example,

> more scientists do research of Nobel caliber than can win the Prize. This results in an accumulation of uncrowned laureates who are the peers of prizewinners. Like the 'immortals' who were not included among the cohorts of forty comprising the membership of the French Academy, these scientists have been described as 'occupants of the forty-first chair'. At any given time, they include, first, the past scientists of genius or great talent who never won the Prize; second, present scientists of the first class who never will; and third, scientists whose past work eventually will win them the Prize (Zuckerman, 1978a:421).

Hence, declaring Nobel laureates a scientific elite is the narrowest and most arbitrary of definitions. When confronted with uncertainties over the validity of some pioneering work, "the Nobel committees have preferred to run the risk of...rejecting contributions that were prizeworthy to running the risk of...honoring contributions that might later prove to be substandard" (Zuckerman, 1978a:422).

Nonetheless, the roster of Nobel laureates represents an uncommon site for a genealogical prosopography. Indeed, Zuckerman (1977: Chapter 4) devotes fifty pages to the filiation of ultra-elite "Masters and Apprentices in Science." From these pages springs evidence for a social heritability hypothesis. To wit: "more than half (forty-eight) of the ninety-two laureates who did their prize-winning research in the United States by 1972 had worked either as students, postdoctorates or junior collaborators under older Nobel laureates"[25] (Zuckerman, 1977:99-100). Unlike Zuckerman (1977: 100), who immediately asks who "have been most prolific in reproducing their own kind through the processes of social selection and training," we may wonder what those "processes" entail. How does ultra-success breed success? What are the fallacies and realities of generalizing from an elite sample to the "mortal" ranks of scientists?

1. The Reality-Fallacy of Rational Selection. Zuckerman (1977:104) asserts that "students of promise can choose masters with whom to work. and masters can choose among the cohorts of students who present themselves for study. This process of bilateral assortative selection is conspicuously at work among the ultra-elite of science. Actual and prospective members of that elite select their scientist parents and therewith their scientist ancestors just as later they select their scientist progeny and therewith their scientist descendants. Thus, Zuckerman posits a calling to the ranks of the (ultra-) elite early in the student's graduate or postdoctorate career. The selection is rational and utterly "unnatural" in that is fixes one's kinship to the mutual benefit of "ancestors" and "descendants" alike. Such "bilateral assortative selection" imputes remarkable wisdom to mentors and students; they can identify promising talent, associate with it, and reserve their respective spots in the history of scientific achievement.

Lest we doubt the impeccable power of rational, but unnatural, selection, Zuckerman (1977:108) supplies some dazzling support for her assertion: "in fully 69 percent of all cases of apprenticeship with laureates, the young laureates-to-be had chosen their masters <u>before</u> the masters' work was conspicuously 'validated' and made fully visible by the award of a Nobel Prize." Significantly, the element of chance is downplayed here. Unnatural selection leads to systematic validation (by awarding of the Prize) of both the master's and the appentice's judgment. Yet scientists themselves, the laureates included (Zuckerman, 1978a:423), insist that the discoveries for which they are often cited and/or feted were "merely" serendipitous (see Austin, 1978). Whether this is false modesty or just more rhetoric, such discoveries nevertheless can and do alter the course of careers. What, in short, passes for wisdom may be bogus (Deutsch and Madow, 1961), i.e., not so noble and profound (Turner and Chubin, 1979). How, then, in the family of laureates, are careers structurally abetted, i.e., socially promoted?

<u>2. The Reality-Fallacy of Sponsorship</u>. A second generalization of the heritability hypothesis follows from the rational selection data: "the eventual laureates, in their youth, had a discriminating eye for the masters of their craft as well as for the major universities and departments doing work at the frontiers of the field" (Zuckerman, 1977:109). Earlier, in "Science as Craft" I recounted the evidence for an institutional "halo effect" which imbues its graduates with a legitimacy or aura of intellectual excellence that few of their "peers" enjoy. Among the ultra-elite, this effect is apparently magnified: laureates who took degrees at elite universities got their prizes earlier than the minority trained at less distinguished universities, while American laureates trained by laureate masters won their Nobel awards earlier than those whose masters never became Nobelists (Zuckerman, 1977:113).

On the subject of sponsorship, Zuckerman exhibits an interesting ambivalence. On the one hand, she dismisses overt politicking of laureate mentors on behalf of their students as the exception, e.g., the case of Rutherford and his student Chadwick (Zuckerman, 1977:106). Politicking, I would agree, is an insufficient explanation for the inbredding of laureates.[26] On the other hand, Zuckerman (1977:132) concedes that

> The role of master includes the role of sponsor, particularly for those apprentices who are judged to be among the best of the lot and promising to contribute notably to science .... Sponsorship often appears as a latent rather than a manifest function when the *established authorities* appraise the work and performance of young scientists, both in correspondence and conversation. Their judgments spread to other scientists at the *centers of influence*, whose recommendations are in turn sought by still others within the national and international community of science (italics added).

Zuckerman's choice of words underscores the *social* in social heritability and sponsorship in general. Later, she describes the scope and effect of an elite mentor's intervention in the launching of a student's career:

> Eminent sponsors are not only better equipped by their *power and influence* to look after their apprentices; they can also increase the visibility of those apprentices. Young scientists are often known, if not finally judged, by the distinction of their masters. And with the growth of big science that brings with it more anonymity, *visibility* may become increasingly important in the early stages of developing a professional reputation. The visibility conferred by having a well known master means, among other things, that the young scientist who has not yet acquired a scientific identity will have

> a better chance of having his work noticed, read, and used than other scientists doing work of the same quality (Zuckerman, 1977:135, italics added).

Zuckerman stops short of predicting that the work of a laureate's student will be evaluated more favorably than that of equal quality produced by a relative unknown. Such a prediction infers that students are selected for their promising talent and sponsored for that very endowment by masters of "distinction." Rather, Zuckerman (1977:134) invokes a familiar "functionalist" belief, claiming that "in the meritocratic system of science elite masters can do nothing for scientific talent that does not come their way or is not at least called to their attention by others...whose judgment they respect." Here Zuckerman falls victim to her own rhetoric. If one believes that science is a "meritocratic system," then indeed "elite masters can do nothing."[27] But Zuckerman's own data tell a different story. Because knowledge claims--to novel findings as well as to promising talent--are socially negotiated, it is naive at best to deny that such negotiation proceeds apart from the "power and influence" of "established authorities" at visible "centers." The social trappings of reputation, visibility, and the acclaimed intellectual excellence of laureates is a rhetorical resource--articulated or not--that exudes legitimacy (and more) by association. It serves to bring the proteges of laureates more resources for research, better jobs, and perhaps more recognition than they would have gotten on their own. While no substitute for talent, this does serve to augment the advantages that accrue to recognized talent (Zuckerman, 1977:135).[28]

Like the reality-fallacy of rational selection, sponsorship speaks foremost to the social component of the heritability hypothesis. But another component, too--more explicitly intellectual, stylistic, and encompassing of the creative tensions inherent in the mentor-student relationship--has been illuminated by Zuckerman's study of the Nobelists.

3. The Reality-Fallacy of Style. If the heritability hypothesis is correct, then as the genealogy of the laureates indicates, elite apprentices in due course themselves become elite masters--perhaps not Nobelists or occupants of the forty-first chair, but scientists of the "first class." But does this social, or status, reproduction imply a stylistic reproduction or continuity? Zuckerman (1977:118) finds that perhaps "more often and sooner than in other strata within science, the roles of teacher and student in the upper strata become transformed into the role of collaborator, particularly in the course of work that eventually brought the prize both to them and their one-time masters." Still, does collaboration with one's mentor suggest a similarity in cognitive style or a complementarity?

At the time of collaboration, we would expect a basic similarity in the approaches of a mentor and his students. Whatever complementarity observed is likely to reflect a division of labor, not a division of intellectual orientation. A strain toward continuity would also inhere in the power differential between mentor and student. Although deference might always (throughout their respective careers) be accorded the mentor by his/her student, this should be no more intense than during the student's pre- or post-doctoral apprenticeship. Unde this condition, one's degree, and therefore, credentials, fate and/or immediate destiny reside with the mentor. Certainly the extent of intellectual antagonism a mentor will tolerate from a student varies with the mentor's style, the student's precocity, and the rapport that exists in their relationship (see Bucher and Stelling, 1977:134-144). Greater intellectual latitude may pervade the mentor-postdoc relationship, and even more may be present in collaboration between a senior and a junior researcher (in a professional age sense) with established reputations in their own rights.

But these conjectures center on the "status transition" aspect of the mentor-student-cum-collaborator relationship. Recalling Kuhn's (1963) conceptualization of the essential tension in scientific research, "convergent" thinking within an established tradition dominates doctoral education in the sciences. Creative impulses must be channeled. This channeling--what we have called acculturation--can be thought of as a suppression or subordination of intellect. It is this "social override" of intellectual impulses that is effectively introduced in the mentor-student relationship. For the tacit dimension of technical knowledge defines a range of permissible problems and appropriate methods for their study. The impact of these cognitive norms is formidable, legitimated by the student's dependence on and trust in the mentor/role model who introduces and enforces submission to his/her intuitions. Hence, trust begets emulation and, in turn, succession. Succession assures intellectual continuity.

Among the elite, however, intellectual continuity does not obtain. Novelty does. Status continuity results from fresh approaches, unanticipated findings, and discoveries of an uncommon kind. Recognition of such achievement, indeed priority, is what supposedly distinguishes the elite from the scientific masses. In order to make such discoveries and inroads to tradition, scientists must break their cognitive bonds, so to speak. What this requires, I contend, is a repudiation of one's training, and of one's mentor.

The genealogy of Nobel laureates suggests that scientists symbolize a filiation of excellence in inducing intellectual change. Yet the route by which their kinship is established may be one of deep estrangement, indeed intergenerational conflict, between mentors and students. The laureates' social union derives from a cognitive disunity. This disunity represents a psychological manifesto that one's creativity and one's style cannot be submerged in, and subordinated to, the style of one's mentor. The point is not the quality of ideas or collective wisdom of the elite--a point seemingly lost on Zuckerman--but the ability and will to assert one's "divergent" thought and manifest one's independence. Perhaps these very proclivities are planted--again tacitly--through the interaction of elite masters and their promising apprentices. If so, the "anticipatory socialization" of the future elite is consistent, remarkably efficacious, and distinct from that which occurs in other strata.

In Zuckerman's (1977:136-137) view, a common theme in the laureates' perception of the teaching role is its elitist orientation. For just as apprentices take pride in having had distinguished masters, masters take pride in apprentices who become distinguished scientists. This vindicates their judgment. But the motivation to concentrate on most promising young scientists is reinforced by more than personal satisfaction with the result. Science confers esteem upon masters whose students develop into first-rate scientists. "Thus direct personal reward and secondary social reward coalesce to reinforce the elite tradition and the strong interest in having outstanding students." This interest is also a self-fulfilling prophecy: after selecting your successors, you are apt to groom them as such. There is an emotional as well as intellectual investment in them. One need not be either a founder or charismatic to have disciples, too. All scientists who relish the teaching role wish to be remembered by their students--a cherished memory in the oral history of science, not merely the subject of adulatory footnotes nestled in the written archives. The scientific ethos seems to thrive on such personal or anecdotal access.

Thus, the ultimate challenge to the reality-fallacy of style among the ultra-elite, however, is not its elitism. Status-consistency and -maintenance for the laureates is a by-product of intellectual inconsistency or novelty. Yet Zuckerman (1977:138-143) devotes little to the ambivalence and conflict that attends the intellectual disjunctions arising in the master-apprentice relationship. In considering the ambivalence of role-inclubents, Zuckerman focuses on the inevitable misallocation of credit (see Merton, 1968) to eminent masters for collaborative work produced with their students. She even states that whereas "time erodes memories of bitterness and conflict between masters and apprentices and that one-time apprentices are reluctant to speak of them,...laureate apprentices probably had particularly benign apprenticeships owing to early recognition of their scientific promise" (Zuckerman, 1977:143). Here Zuckerman betrays an indulgence of her eminent subjects and their rhetoric (or lack of it). Given the status transition of laureates' students to the ranks of the elite, their apprenticeships can be called anything but "benign." Surely the transition itself is little more than bestowal of the "halo" on the neophyte, and thus more status-maintaining than -ascending.[29]

Reproduction, and thereby perpetuation, of the elite, seems not to be a process of knowledge acquisition per se. That is "the least important aspect" of the apprenticeship. Rather, "it's the contact: seeing how they [the mentors] operate, how they think, how they go about things ... It's learning a style of thinking" (Zuckerman, 1977:122). In terms of the Gordon and Morse (1969) typology, the laureates' style would approximate that of Integrator. "For among the elite scientists, the prime criteria of scientific taste are a sense for the 'important problem' and an appreciation of stylish solutions. For them, deep problems and elegant solutions distinguish excellent science from the merely competent or commonplace" (Zuckerman, 1977:127). Neither the Problem Solver nor Problem Recognizer would possess the requisite cognitive skills to do excellent, e.g., prize-winning, work. On this, the laureates are unequivocal: they "assign special value to their powers of intuition and ultimate success in solving intractable problems" (Zuckerman, 1978a:423).

> A sense for 'the right kind of question' and for the character of its solution develops during interaction between masters and apprentices and among the apprentices themselves as they pass judgment on the quality of scientific work, new and old, their own and that of others. It develops also as they speculate about the direction their field 'should take,' identify gaps in basic knowledge, and argue about which problems are 'ripe' for solution at the time and which are not (Zuckerman, 1977: 128-129).

If the laureates, and by extension, the forty-first chair occupants, share an "integrative" cognitive style, the stratification system of science towers as a hierarchy of socially-induced and -enforced psychological capacities.[30] Those scientists who can both recognize and solve outstanding problems, according to this formulation, comprise the top-most stratum. If we subscribe to Zuckerman's interpretation, elite training is a "stratification of experience" that replenishes intelligensia (as discussed in Chapter 1). Those below the preeminent are presumably a more heterogeneous population of scientists with respect to talent, motivation, style, and career success. Without the requisite intellectual endowment, but moreover, exposure to elite mentors, students rarely achieve eminence and membership in the Nobel family. For this majority of scientific personnel, social status and intellect never quite mesh. Students never realize mentors' expectations because the mentors themselves never harbor them. Excellence of the first rank is beyond the compass of their craft. Consequently, they are forever sentenced to toil as Problem Recognizers, Problem Solvers, or Technicians.

4. Distinguishing Reality from Fallacy. I have tried to indicate how Zuckerman's analysis of the ultra-elite suffers from a determinism that (i) endorses the stratification system as rational, (ii) misallocates to mentors and students alike a collective wisdom that cloaks a combination of institutional clout, structured opportunity, and individual chance, and (iii) confuses social heritability and cognitive style. Have I reduced realities to fallacies?

First, consider that a primary function of any stratification system is self-preservation. Of course, different perspectives on social reality are afforded those who occupy different social statuses. Those in the most privileged status seek to perpetuate their advantage. In Westie's (1973: 20) words, "a major means of self-perpetuation is the development of a 'culture of legitimation,' consisting of attitudinal, valuational, and normative precepts, as well as cognitive definitions of reality, many of which are patently mythical." To accept the Nobel prize and the ultra-elite as signifying the best science and scientists, respectively, smacks of hubris of the most invidious sort. As Zuckerman (1978a:425) laments, "we do not know whether the Prizes have actually advanced science or significantly affected its directions of development." What we do know is that the prize has advanced the careers of laureates, boosting their status to that of celebrity and sage, while enhancing their influence (rhetoric) over resources and students. Science, like other institutions, needs its heroes and "mediators" (Mulkay, 1976b). This alone, however, renders the system neither rational nor just.

Second, as agents for a social system, mentors must socialize incoming generations of students to the "culture of legitimation." Such collective justification should not be mistaken for collective wisdom. Recruitment to graduate departments is a competitive process of selection and self-selection. Institutions, organizations within them, and the individuals affiliated with each, deploy their resources--money, reputation, contacts, and rhetoric--to lure future generations to "the calling of the craft." Those with the opportunity to listen--for whatever reason--become candidates of greater or lesser promise, apprentices to greater or lesser masters. All, it seems (Westie, 1973), have unrealistically high expectations for "professional immortality."[31] An inflated conception of our importance, and that of our work, may be healthy. That it is systematically present--engineered into and rewarded--in the top-most stratum of the stratification system, or only among Nobel laureates or other elites, strains credulity.[32] For the process of recruitment, selection, and training is too fraught with idiosyncrasy, serendipity, and ignorance to warrant claims about "wisdom." The ends neither justify nor explain the means. The reality of receiving a Nobel prize signifies a success, not a self-evident truth.

Third, the social heritability hypothesis prompts a search for data that discern intellectual and psychological differences, e.g., in risk-taking among the members of the Nobel family, especially direct ancestors and descendants. Though the social bases for the laureate genealogy are convincing, they are not sufficient to account for the linkages that exist. What are the traits and conditions associated with novel, prize-winning work is not a question that has a "structural" answer.

Cognitive style is an <u>intra</u>personal as well as an <u>inter</u>personal trait; it springs from one's psychological-emotional makeup, but is shaped by one's intellectual-social experiences. If style is intimately bound with one's tacit knowledge, then the necessary data will not be readily available. For we still do not know how scientists "attach symbolic expressions to nature" (Kuhn, 1977b:301). Rhetorical forms legitimate and obscure this "language-nature link." It is what the scientist does not say or write that may hold the key to his style of thought and work. The malleability of the human mind notwithstanding, no uniformity of style, e.g., Integrators, should be found within any stratum of science. Indeed, it is plausible that individual differences should be accentuated by the graduate school experience. To argue otherwise is to caricature the mentor as "indoctrinator" and the student as "willing supplicant."

Yet the laureate genealogy is a social fact. And the conclusion toward which we have driven is that the filiation among Nobelists exceeds what we should expect or is deserved. Baldly put, quality of intellect and novelty of work do not necessarily culminate in the Nobel prize or, for that matter, in "lesser" forms of recognition. Excellence of knowledge claims and skill in negotiating their acclaim are important ingredients. Indeed, the reputations of one's mentor, department, and institution--then and now--all affect the probability that one will receive the prize or other accolades. The Nobel committee is fallible, the criteria manipulable, the elite's experience nongeneralizable.

How, for instance, do "mortal" scientists--accomplished but not luminaries, researchers but not necessarily prolific, Ph.D.'s but not mentors, mentors but without many students--evaluate their graduate experience? What do they recall about their relationship with their mentor? How does their mentorship styles differ? And in what ways have their early careers unfolded per their expectations? Is social heritability a tenable hypothesis for all scientists or a phenomenon peculiar to its elite? Is heritability really hubris? An empirical assessment of these questions follows.

The Graduate Training Experience of Mortals: A Ten-Year Retrospective

Surveys of scientists' attitudes toward their training, professional responsibilities, and career prospects are by no means novel (e.g., Blissett, 1972; Cotgrove and Box, 1970; Fulton and Trow, 1974; Anand and Haberer, 1978). But none have taken as their primary focus the terminal period and product of most graduate training--the research and writing of the doctoral dissertation. In late 1978, a colleague and I undertook such a study (see Porter, 1978).

Our survey was a six-page questionnaire mailed to a random sample of scientists in six disciplines who received the Ph.D. from U.S. universities in 1969-70.[33] The disciplines represented were physics, biochemistry, zoology, psychology, sociology, and electrical engineering; they were selected for their diversity and our collective familiarity with them. More important, 1969-70 were watershed years in American Ph.D. production. They are an unmistakable point of inflection in the growth curve of doctorate manpower (Harmon, 1978:10). The downturn reflects the several interlocking forces--the intensification of U.S. involvement in Vietnam, a declining academic market (especially for natural scientists and humanists),[34] a concomitant increase in postdoctorate positions as a "holding pattern" for new Ph.D.'s waiting for the economy and the job market to recover. That the market never recovered is one reality with which our sample has had to cope during the first quarter of their professional careers.[35] This is another reason for selecting the 1969-70 cohort: it provides a decade of the scientist's career to assess the role of the Ph.D. dissertation, in the words of our cover letter, "its importance as a source of scientific knowledge, as a way of learning how to perform research, and as a requirement in earning the Ph.D."

At the same time, ten years is not so long that experiences surrounding the dissertation should have faded from memory. An overall response rate of 70 percent attests to this fact.[36] What is most significant for our present purpose is that 38 percent of the respondents accepted our invitation to "amplify and comment further" upon their answers to closed-ended questions "wherever appropriate." (The proportion offering comments varied by discipline, ranging from 32.5 percent of the zoologists to 41.8 of the sociologists.)

Of particular interest are the remarks subsumed under Question 10 in the survey, a series of queries about "the role played by your dissertation supervisor and committee." Overall, one-third of those respondents who shared their recollections and opinions in written form <u>anywhere</u> on the instrument commented on "other characteristics of the supervision you received that affected the value of your dissertation experience."[37] The commentary is far from uniform, a finding which underscores both the idiosyncrasy of the experience and its enduring impression on the scientist. For those who were moved to comment, the passage of time did little to erode the vividness of the experience then and its retelling now. Contrary to Zuckerman's presentation of the laureates' perceptions, ambivalence is a recurrent theme, though positive retrospective evaluations slightly outstrip the negative.[38] A sampling of anecdotes which typifies the spectrum of opinion expressed on the mentor-student relationship and its value in career development (and with hindsight, in the dissertation experience itself) is presented below. Admittedly, the most quotable excerpts are included. Regardless, such commentary is a much-needed complement to the laureates' anecdotes reported in Zuckerman (1977) and featured as elite opinion above.[39]

The commentary is organized into thematic sections that address many of the foregoing "realities and fallacies" regarding the mentor-student relationship, especially as a source of "conflict" and "inspiration" (our words). Only where helpful for interpretation is the discipline of the respondent-scientist appended to the remarks, i.e., most are omitted.

1. Ambivalence Over Apprenticeship

> Despite the dangers of explortation of students and triviality of dissertation research, I am inclined (regretfully) to believe that the most efficient training for research can be gained in apprentice-like situations in large academic research organizations.
>
> I believe then, as now, that the Ph.D. was an 'apprenticeship' in the old sense of the word: 'learn from the master.' I was expected to surpass the 'master.'
>
> Without the experience of the dissertation, traumatic as it was, I do not think I would hold such value for scholarly research...
>
> It is like combat: if you survive, it is nice to have had the experience, but I wouldn't recommend it to anyone.
>
> It was a very enjoyable, worthwhile, learning, humbling, memorable experience. I needed to go through it.

Perhaps the better part of apprenticeship is mentorship. Herewith are perceptions of mentors' performances as dissertation supervisors. Most seem undulled by the years; indeed, they possess candor and conviction.

2. Mentorship: Good, Bad, and Indifferent

> I find my supervisor to be an exciting person intellectually and a strong supporter of myself and my work throughout my career--a true mentor and man I deeply respect and care for. This greatly affected the experience I had.

> I was greatly influenced by two renowned_______ professors...whose research I extended. While they were on the other side of the country...they advised me by mail and I went over the proposal with them in person. They also encouraged the dissertation's publication and continued work in the field.[40]

> He had the wisdom to leave me alone and let me make my own mistakes, but gave me guidance when asked to.

> My advisor became a close personal friend who gave moral support throughout.

> He left me alone to take full responsibility for my research [and] provided a decent role model for [doing] critical thoughtful research.

> He provided invaluable insight and judgment...and he always dealt with me in a fair and adult way that never demeaned me or my efforts.[41]

> Dr. ________ is a very warm and open minded fellow who loves new ideas.

But the sins of the fathers are many--if we take the unsparing criticism of their offspring as a stern indictment of pedagogical virtue. To wit:

> I had conflicts with the advisor. He wanted to use Ph.D. students as "slave labor" for his own glorifications, i.e., papers.

> My supervisor was not really familiar with the [research] area. He was living and building

> his reputation on the work of his graduate students.
>
> I wasted 1½ years in the problem-formulation step since my first advisor was incompetent technically.
>
> My supervisor was too busy managing a 30-member ________ group to really spend time with his students.

These negative appraisals of mentors' exploitation, ignorance, and preoccupation with administrative duties no doubt detracted from the dissertion experience and, in the student's mind, the value of the research itself. For some, however, the psychological toll was considerable, lingering even today.

> I paid a tremandous cost in psychological stress. It is a very painful experience for one who is isolated, insecure, [a] perfectionist...
>
> I had the fortune and misfortune of selecting an advisor who was chiefly oriented toward generating Ph.D.'s. He systematically rushed his students through. The dissertations of his students, including myself, passed primarily through his political influence. The result for me and several other of his students...was a poor quality dissertation, achieved on a forced schedule, which kept one in doubt over one's real abilities...a very clear sacrifice in pride, training, and quality of work.
>
> The atmosphere was combative rather than supportive, and therefore a serious psychological strain.
>
> Conflict with my supervisor was so intense that my dissertation and the area of research became aversive.[42]

The sin of indifference would seem to pale compared to those alleged above, but to some was traumatic nonetheless.

> It was a lonely battle rather than an exciting adventure.
>
> There was no supervision....You 'finish' a little ignorant but resourceful and fairly tough.
>
> I was virtually left alone but with a standing invitation to see Dr. ________.

What emerges from these comments is a rueful acceptance of unfulfilled expectations. What makes graduate school in general and the dissertation experience in particular "lonely," may help the neophyte become, in retrospect, "resourceful and fairly tough." In other words, nurturant supervision may provide the emotional support for one student while engendering resentment from another, e.g., one who craves independence.[43] Our respondents protested both of these styles suggesting that the fault does not lie with the mentor but with the relationship between mentor and student. In some cases, conflict in personality, outlook, and style led to open hostility and/or replacement of the supervisor:

> Dr. ________ was a very disagreeable man. I'm sure he also viewed me that way. Remember, in 1969 there was student-faculty unrest.

Sometimes committee members served as a buffer:

> The greatest contribution was made by a visionary committee member who pointed me into the right topical area but did leave details up to [my] chairman.

Still other times, the student's own naivete was confessed:

> I went to graduate school for what many would consider to be all the wrong reasons. However, I

> couldn't be happier with the life it has led me to. I must give credit to my sponsor...who knows how to stimulate, as well as how and when to push a student.

Among those--a handful--who alluded to recruitment to a particular graduate school, almost all felt their judgment was vindicated by the experience.[44] For others, self-recrimination and regrets abound. These take at least two related forms--(i) belittling the doctorate degree as process (necessary evil) and symbol (union card), and (ii) lamenting career strategy upon denial of tenure or unemployment due to retrenchment by one's employing institution.

3. <u>The Ph.D. and Career Outcomes: Regrets and Lamentations</u>

> The Ph.D. has only aided by advance by giving [me] the needed credentials....My master's program did much more for my career [a physicist].

> I considered the Ph.D. as a 'license to practice' at the university level [a biochemist].

> I consider my Ph.D. to be my 'union card' which 'qualifies' me to do independent research. I was capable of it before the Ph.D., but apparently I needed those 'credentials' to do the kind of...research and teaching that I wanted to do [a zoologist].

> Graduate work today I find far too highly specialized. We are turning out miniature idiot-savants.

> I have an embittered feeling toward the politics of higher education...I was unfairly terminated from a profession I dearly enjoyed because of the tenure situation. When enrollment dropped, I was cut first because I was next in line for tenure...

> I was denied tenure at a time when openings in my field [were] almost non-existent...[and have been]

unemployed since July 1978.

While these fragments are juxtaposed and otherwise arrayed to connect current views and career decisions with graduate school experiences, they lack individual histories of intervening conditions. Such histories would explain why, for instance, devaluation of the Ph.D. appears to be widespread among those pursuing their career within academe, whereas a yearning for such employment punctuates the commentary by tenure casualties. How great is the disjunction between the expectations of the young Ph.D. and the reality of his/her pursuits ten years later? How much of that behavior is a replication of, or aversion- -to the style of one's mentor?

These and other questions cannot be definitively answered by the commentary elicited by our survey. But such questions do fall within the purview of the social heritability hypothesis which prompted the investigation which this chapter, and especially this section, have crystallized. What remains is a comparison--impressionistic as it may be--of elite graduate experiences and those of mortal scientists. This will be followed, in the concluding section of this chapter, by an integration of these findings into our conceptualization of science as craft work.

1. The experiences recounted by our sample of scientists trained in six disciplines and awarded the Ph.D. in 1969-70 are far more heterogeneous in content than those recounted by Nobel laureates. The laureates' anecdotes emphasize, in almost uniformly glowing terms, research and apprenticeship. Mortals paint a sometimes vivid picture of their mentors; it is also a fuller picture of mentor _qua_ supervisor and friend, not just colleague and collaborator. The difference may be hubris.

2. Mortals harbor less grandiose expectations of professional immortality than do elite scientists. Though professionally younger and

less accomplished than the laureates, the mortals' retrospectives on their graduate experiences betray a stirring of deep feelings. The commitment to career seems counterbalanced by sensitivity to the psychological strains inherent in the career. The result is ambivalence: pride, regret, and recrimination—reinforced and constrained by career decisions (e.g., to attend the university of X), organizational exigencies (e.g., mentor's research grants) and outcomes (e.g., research speciality migration[45] or tenure casualty). Another result is an invisible professional heritage--a genealogy that exists, but is never reconstructed or made manifest.

3. This is not to say that elites never fail. As argued earlier, they can afford to. However, they do so with less frequency and have a knack for projecting an image of success. In general, they don't talk or write reflexively.[46] Their words are stylized; their command of resources extends to rhetoric which they adroitly manipulate. Such propitious negotiation is commensurate with "haloes;" haloes beget "auras"--of technical competence, tacit knowledge, infallibility, and wisdom.

The upshot is that generalizing from elite experience is premature. While the evidence of mortals' experiences seems contradictory, it is also not comparable. The same questions are rarely even put to these two populations because they are identified as distinctive on analytical instead of empirical grounds. I, too, am guilty of such reification. For instance, the "comprehensive" survey cited here contained no explicit cognitive style items, though epistemological and problem choice items were included.

To extract a subset of professional roles that scientists play from their context in the "whole person" is to over-simplify a multidimensional phenomenon; like other mortals, scientists may segment their lives, but not their psyches. What occurs is one realm of experience intrudes into another. Analyses of scientific work--creativity and careers--must embrace a "Humpty Dumpty" mentality if they are to distinguish these realities from fallacies. Perhaps in our quest for understanding the mentor-student relationship--as a critical microcosm of social interaction, of dyadic trust and tension--we have begun to put the multidimensional scientist "back together again."

CONCLUSIONS ON CRAFT AND CAREERS: SCIENCE AS NEGOTIATED ORDER

This chapter has been predicated on a conception of science as craft. The processes of craft work, detailed by Ravetz (1971) and extensively recounted, entail an array of theoretical notions. Such notions as "tacit knowledge" and "essential tension" posit a corresponding empirical reality too seldom tested. That reality, upon even cursory inspection, extrudes its thoroughly social character. First, we appraised the normative aspects of scientific craft work. Next, we traced these norms to the institutional and organizational contexts in which they are enmeshed, promulgated, and acculturated. Finally, we probed the social-psychological counterpart of technical knowledge and norms, suggesting that "cognitive style"--one's epistemology and rhetoric--looms as a largely unmeasured resource in creativity and its accumulative recognition as career success.

Taken together, then, these observations and speculations call for closer inspection of those processes experienced at the very beginning of the scientific career. The focus becomes the graduate training period, particularly its latter phase where a mentor-student relationship begins to evolve. From this focus a central hypothesis emerges, that concerning "social heritability." Prosopographical evidence on the careers of American Nobel laureates, an ultra-elite among the elite corps, supports the hypothesis that the most culturally-acclaimed scientists are linked intergenerationally--systematically--to other like-accomplished luminaries.

But to inquire as to the generalizability of this finding is to raise a host of questions--doubts and dubious suppositions--about filiation in science. How much of the eminence is socially inherited? What exactly is transmitted from mentor to student? How does the elite differ, in academic origins and personal style, from the mortal masses of scientists? In attempting to speak to such questions, a sampling of commentary from "mortals" elicited as part of a recent survey of 1969-70 American Ph.D. recipients in six disciplines was presented. Though fragmented, these anecdotal data caution that the heritability hypothesis has been sustained in the breach. The gulf between fallacy and reality in distinguishing genealogy among scientists--as intellectual tradition, stylistic facility, or institutional hegemony--has only begun to narrow. It must narrow further if answers to the above questions are to be forthcoming, and if scientists' career patterns are to be delineated intellectually, pyschologically, and demographically. For now, one analyst's reality is another analyst's fallacy.

An intellectual and psychological delineation of careers, however, must rely, at least in part, on a perspective of socially-constructed scientific reality. For if we adopt the perspective that science is a negotiated social order, then social heritability and Westie's (1973) companion notion of "professional immortality" compel an examination of the "personal and intuitive on the one hand, intersubjective and consensual on the other--out of which theories, interpretations, meanings and realities are constructed" (Ziman, 1978:155). It is in graduate training that a mentor shares his/her "mental domain" or intuitions and the student "senses" that technical and tacit knowledge are cultural resources. The rite of passage from student to certified (Ph.D.) scientist, however, transforms these resources into tools of style. Stylized, these tools (or trappings) are idiosyncratic, renewable, and manipulable. They were negotiated, but persuasive, as a mentor's craft in graduate school; they are negotiable and rhetorical as student-cum-scientists' craft in his/her own post-Ph.D. career.

Ironically, unless we construe the laureates' careers as due to an extraordinary collective wisdom, failsafe rationality, and homogeneous "diverger" or "Integrator" style, we must discredit the collective judgments of the mortal scientific community. The inescapable zero-sum element in this conclusion stems from the fact that the elite of science is still a numerical minority. Yet their self-interest and solidarity in maintaining control of rewards and access to opportunity--in short, dominating the masses --is evident.

If cognitive styles are distributed throughout the community, i.e., at various institutions, then novelty, too, should reside there. Whether novel claims emanate from all quarters is disputable. But of those claims that are made, their recognition--in the presence of great uncertainty--will depend on more than technical content. The cognitive norms--particularism, solitariness, interestedness, and dogmatism--assure that. To be sure, such an assurance is a reminder that professional reward and craft work are not one and the same. Inferring one from the other is indicative of the hubris and stratification of experience, i.e., ideology, advanced earlier.

Because novel work, to paraphrase Ravetz (1971:124-125), is frequently done at the limit of the capabilities of the existing tools for producing reliable results, the assessment of the strength and fit of the evidence can become very subtle indeed. There inevitably arise disputes about the inadequacy of the solution to the problem which cannot be resolved either by scrutiny of the data or by an appeal to accepted criteria of adequacy. Thus at such points, the "objectivity" of scientific knowledge breaks down. In the long run, further work may decide the issue; but the decision on whether to engage in such further work, which partly depends on the assessment of the adequacy of the controversial piece, must be taken now. Thus, at such critical junctures in the research process, the assessment of the evidence adduced in an argument becomes a crucial judgment. Individuals are thrown back on their own personal resources and forced to make risky judgments, lacking the safe channels of an accepted tradition to steer them towards the "correct answer."

But risk they do; and if they are "correct," they may attain the auspicious status of Nobel laureate. If they are incorrect, some still prevail, retaining the elite "halo and aura" at their behest. Such is the power of kinship and rhetoric. Not all scientists share that power. Indeed, most don't. Thus, examining elite career patterns is only the intelligentsia's exhibition of craft work. We mortals must do more to reveal the fallacies of reconstruction and rhetoric that elites and mortals alike employ. The "more" is the craft of our science.

NOTES

1. This imagery refers, respectively, to students (i) whose mentor is publicly invisible or "unknown," (ii) whose reputation, style, or research specialization differs markedly from that of one's mentor, and (iii) whose career seems to imitate--either in its eminence or modesty--that of a mentor (or major teacher). This variety of "academic filiation" patterns has never been conceptualized beyond schematic presentations of kinship ties (see note 23). Such ties identify prolific mentors as intellectual or organizational "leaders" (Mullins, 1973) who found "schools" and attract disciples. Little is systematically known, however, about how and why scientists become intellectual "kinfolk," and indeed, claim to be "polygenetic."

2. Although Ravetz distinguishes the craftsman from the scientist and the technician, science is seen as a special kind of craft. I prefer to blur the distinction and, at the same time, avoid the sexist terminology. Henceforth, "craft-scientist" will be abbreviated to "scientist."

3. Students who abort their careers in graduate school are commonly thought of as flawed or handicapped, i.e., emotionally or intellectually unable to cope with the rigors of graduate study. These "failures" join the ranks of attrition. While their motives for career switching remain obscure, we can look to the system of "sponsored" and "contest" mobility for some answers (see R. Collins, 1968; Hargens and Hagstrom, 1967; Hargens and Farr, 1973). Certainly the fit--psychological and intellectual--between a student's and a faculty's expectations also contributes to the continuation or suspension of a career in

science. Among the contrasting treatments of this under-studied fit, two are notable. Zuckerman and Cole (1975), are blatantly psychologistic in their attempt to reconcile sociological findings on sex discrimination in science with a structural-functional (pro-universalism) framework. Laws (1975), on the other hand, explores the political context for appraising psychological and intellectual fit. She offers an incisive analysis of the role partnership between "Sponsor" and "Token" within a "gender-class system." Here the dominant class of the former and the deviant class of the latter perpetuate the institution of tokenism. Whereas the present discussion does not address gender linkages in the mentor-student relationship, data on sexual liaisons as a political tool are now coming to the fore (e.g., Fields, 1979). My purpose for raising the issue here is to suggest the more general applicability (i.e., beyond gender) of Laws' analysis to the conceptualization of social heritability in science.

4. A systematic rebuttal of Merton's critics is claimed by Gaston (1978: 160-180) who reaffirms the "power of evidence" over "insufficient data" and "pure conjecture." Instead , Gaston caricatures the criticisms of the ethosand simply misses their point. As Ziman (1979:676) allows, in a review of Gaston's (1978) book, "Jerry Gaston is a faithful Mertonian and a good deal of [the book]...is a spirited defense of the norms...[B]ut this defense is rhetorical and argumentative rather than truly compelling."

5. This revelation, by the way, may account for the embrace of Kuhn by European, and especially British, sociologists as an alternative to Merton's "sociology of scientists." Throughout the 1970's many an article in the European science studies literature acknowledged its roots in a "neo-Kuhnian historical sociology of scientific knowledge" program. Upon unpacking this program one realizes that the wedge driven between Merton and Kuhn is a flimsy ruse indeed; they are fully compatible (see Chubin, 1978a) though the troops still rally round one or the other, it seems.

6. Each of the terms in Merton's (1942), while the "counter" terms are used by Mitroff (1974b:592).

7. For example, the selective reading and scrutinizing noted under universalism-particularism might anchor what Mulkay (1974b) calls the scientist's "implicit theory of citing." Making these theories explicit requires unorthodox citation analysis (e.g., Chubin and Moitra, 1975; Gilbert 1977; Small, 1978). Relying on bibliographic patterns certainly precludes the connection of technical rhetoric with tacit knowledge since such patterns take the former as an accurate re-

presentation of the latter, and deny the self-serving occupational ideology as a motivational force (see Knorr, 1977; Woolgar, 1981).

8. Ravetz's (1971:95-96) discussion of "pitfalls" illustrates this point:

> For the [research] assistant will generally know what his supervisor expects to find; indeed, he must have such explicit expectations if he is to make the first judgements on the soundness of the data. But when unexpected and contrary results appear, he must make a judgement on their significance, balancing his own limited technical competence against the superior understanding of his master, and perhaps, being influenced by political considerations as well. The natural course of action is to present information from which anomalous data have been expunged.

Thus, while "expectations" of findings and "judgements of their significance" are epistemological considerations, the "natural course of action" is both (counter) normative as a behavior (i.e., "to expunge") and rhetorical in the ultimate reporting of findings and their significance. The differentiations which we social analysts make are not those made by scientists themselves; at best, they are latent in their craft work and coaxing them out--a probing for pitfalls--is nearly taboo (Kuhn, 1977b: 305). A few ethnographers, however, have now penetrated the inner sanctum of laboratory life and begun to translate scientists' technical-tacit knowledge for outsiders (see Chapter 4).

9. The rationality of science--a myth of momentous proportions--has been an issue consciously deferred in this chapter thus far. While the apparent incongruence of "rationality" and "belief" may disturb the reader now, I will address this below and again in the concluding chapter.

10. Free-lance or avocational science passed into oblivion within a half-century of the founding of the Royal Society. By the early eighteenth century, science took on the trappings of a full-fledged occupation and soon thereafter, of a profession. For various perspectives on this metamorphosis of "the scientist's role," see Mendelsohn (1963) and Ben-David (1971).

11. In facetiously singling out "this idyllic state of affairs," Whitley (1977:22-23) is lambasting the myth-sustaining function of both the Mertonian norms and the cosmopolitanism of scientists as implied by "paradigm" communities. What Whitley is insisting is that local organizations and workaday tasks form the primary reference for the conduct of scientific work; they mediate one's response to knowledge claims and current intellectual issues. The spiritual forerunner of Whitley's concern--besides his own work with Bitz et al. (1975)--is Pelz and Andrews' (1976) program on "scientists' organizational environments."

12. Furthermore, These processes are anything but random. Evidence on selection processes of and by faculty and students overwhelmingly suggests patterns of informed contact, placement networks, and systematic linkages between undergraduate origins and graduate school destinations, doctoral origins and first postdoctoral job placement, etc. (see Caplow and McGee, 1958; Crane, 1965; Hargens and Hagstrom, 1967; Folger et al., 1970; Harmon, 1978; Reskin, 1979). I return to this phenomenon later when the "social heritability" hypothesis is explored empirically.

13. This is an important reminder that the mentor-student relationship need not be one-to-one, but may indeed entail supervision by many teachers (polygenesis). The conventional system of doctoral dissertation committees (found in theoretical physics as well as political science)

takes a qualitatively different form, I would argue, from the "on-the-machine" interaction that typifies experimental physics projects and the advanced graduate instruction therein.

14. In Ravetz's (1971:100) words,

> Everyone who supervises research students knows of the dangers of giving too much, or too little, help and guidance. If the student is simply left to his own devices, he may spend so many months floundering among failed attempts...that he becomes completely discouraged and gives up before he has produced anything solid. But, if he is given constant advice, he proceeds all too smoothly through this project, being little more than a reliable pair of hands for executing the supervisor's ideas; and he never learns to grapple with his materials or to sense the pitfalls occurring in his field. How much help should be given depends on the project, the student, the policy of the school, and the attitude of the supervisor. Research supervision is itself a craft, the most subtle and demanding sort of teaching.

15. For this reason, Whitley (1977:44) suggests that the reproduction of scientists' skills and interests occurs at both the Ph.D. and postdoctoral levels, with control exercised at the entry points of each. Thus, postdoctoral fellowships become a crucial selection stage for new scientists (also see Reskin, 1976).

16. Thus, Pelz and Andrews (1976) speak of productive work climates which generate creative tension among team members. Multidisciplinary collaboration on a single problem is often blessed as the university's vehicle for creating such tensions; it is simultaneously an admission that the excitement and satisfaction formerly emanating from single-

discipline departments must be recovered from elsewhere on campus (see Bess, 1973; Friedkin, 1978).

17. This mapping is due chiefly to Anne Roe's (1953) case histories. Her work remains definitive yet disconnected from other traditions, especially the sociologies of science and of knowledge, which are notorious for seasoning their generalizations about social structure with liberal attributions of motives and other cognitive processes of scientists (see note 3; for reviews, see Fisch, 1977; Mahoney, 1979).

18. Such standardization is implied in oft-repeated truisms about the Harvard product" or the "Chicago school." The meaning is clear: The graduate training experience in certain departments is distinctive, even more "homogenizing" of the students who survive it than training in less structured, (un)orthodox, unproven programs. When the decentralization of federal training funds began in 1970, the "proven" programs at the 60 public and private institutions responsible for producing the bulk of the Ph.D.s in the U.S were declared an endangered resource (Kidd, 1973). The lament was "Why penalize the best and jeopardize the preeminence of the U.S. in world science and technology? Like some (e.g., Vaughan and Sjoberg, 1972), I've always found such "brain drain" and "centers of excellence" arguments specious and more than a trifle elitist in both their assumptions and conclusions,

19. I am not equating the "productive" with the "creative" scientist. Oftentimes, productivity inhibits creativity by sacrificing the quality of novel ideas for quantity, e.g., Cole and Cole's (1973) "mass-producing" scientist. We might wonder, therefore, whether "convergers" disproportionately populate certain sciences.

20. As reviewed in Chubin (1976:465-70), such a scientist is deemed a "migrant," an intellectual deviant who sees connections and potential applications which most others miss. Migration can become a career research pattern for some, especially those with the credentials in one area to warrant risk-taking in another. But these are still the exception!

21. Prosopography or collective biography represents such an historical demographic approach to understanding the peculiar significance of a selected aggregate of contemporaries. The purpose is to reveal the ethos of an era through the collective life of its protagonists (see Shapin and Thackray, 1974; Pyenson, 1977; Studer and Chubin, 1980:Chapter 2).

22. I have deliberately used the word "acculturation," as opposed to "socialization" or "indoctrination," in referring to the <u>process</u> by which technical and tacit knowledge, and its attendant norms, is internalized. I would contend that my choice is apropos of the integenerational transfer--sharing and stylizing--of craft skills. For, as Ziman (1978:124) states, "It is not merely that indoctrination... is antipathetic to the criticism and skepticism that are essential to the research professor. It is that specific concepts only become <u>real</u> by practical use."

23. There appears to have been only one attempt to construct a kinship tree (forest?) for an entire discipline, namely, physiology (Gerard, 1958; but see Crowley and Studer, 1975). That study was designed, however, to encompass only the "institutional and personal genealogies for most departmental chairmen and presidents of the American Physiological Society" (Gerard, 1958:269), rendering the impact of the great majority of doctoral recipients on the discipline unknown. A preoccupation with founders and disciples, the eminent and visible, has yielded fascinating portrayals of "coherent groups" (e.g., Griffith and Mullins, 1972; Krantz, 1971; Mullins, 1973), but engendered no comparable evidence on less manifestly successful scientists. Relationships involving dyads and other small groups of "trusted assessors" (Chubin, 1975) formed through mentor-student, local colleague, and cosmopolitan research (i.e., collaborative) ties would seem to constitute a more representative sample of experiences (examined below) among the rank-and-file Ph.D. population.

24. Two decades ago, Berelson (1960) observed that the reputation of one's graduate degree-granting institution leaves an "indelible mark." Over the life-cycle of a career, the mark will fade, but seldom does it vanish completely, acting for many as an expedient to achieving certain goals, and for others as an impediment to achievement (Chubin, 1974).

25. Besides this broad definition of "student," some details are instructive: (1) the percentage of American laureates with laureate masters varies from 43 percent in physiology-medicine to 61 percent in physics, and (2) the rate of laureates who have had laureate "kinfolk" has remained at 48 percent since 1925 (Zuckerman, 1977:100).

26. Nevertheless, Zuckerman (1977:106) allows that the procedures of nomination and election specific to the Nobel prizes may favor the scientific offspring of Nobelists in the sense that laureates are likely to be skillful advocates of their candidates and having permanent rights to nominate, acquire experience and judgment about the kinds of documents that must be submitted to make their case. Skillful advocacy, of course, amounts to a rhetorical manipulation of "the facts" so as to reflect most favorably on the accomplishments of the Nobel candidate. See Kash et al. (1972) and Boffey (1975) for similar evidence on election to the National Academy of Sciences.

27. As one reviewer of Scientific Elite says about Zuckerman, "her brand of functionalism if Pollyannish and uncritical" (Rosenblum, 1979:675).

28. It is past due to point out that the talent completing graduate study occupies the right tail of the distribution of intellectual aptitude in the general population. The range in intelligence (IQ) is rather restricted, extending from a lower bound of perhaps 115-120 to an upper bound of "genius" (variously defined as 150 +). The "sacred spark" of creativity (Cole and Cole, 1973) that differentiates gifted talent from the rest, therefore, may be motivation, the distribution for which is unknown, or at best, poorly measured. As proxies for motivation, elapsed time between receipt of baccalaureate degree and receipt of Ph.D. and undergraduate grade point average have been used (see Folger et al., 1970).

29. Zuckerman (1977:123) concludes that in terms of social stratification, the laureates' students "were being socialized for positions in the aristocracy of science. Seldom explicit, this was often tacitly understood...[W]ith few exceptions, they would become very good rather than run-of-the-mill scientists."

30. The psychological mechanism by which elite masters evoke superior performance is postulated by Zuckerman (1977:125). They induce "a feeling of obligation, a sense of reciprocity requiring the apprentice to justify through the quality of his work the master's decision to invest time and effort in training him." The mechanism thus assumes the form of sanctions which the master can impose, severe and unrelenting criticism, and general intolerance for "shoddy work, laziness, or plain stupidity" (Zuckerman, 1977:126).

31. Such expectations are routinely frustrated, however, because "Once a particular view of the discipline has become institutionalized and legitimate topics and approaches specified, reformulations and novel developments will be strenuously opposed since they imply a reordering of priorities and threaten the existing distribution of expertise and property rights" (Whitley, 1977:32; also see Chubin, 1976:459-465).

32. Suppose the cognitive risk-taking incurred by the conduct of unorthodox, and ostensibly prize-winning, research is not so costly after all for students of the elite. Boldness and impetuosity may come with the "halo," insulating them from charges of charlatanism to which "lesser lights" of the commuhity might be subjected were they to propose the <u>same</u> ideas. Never underestimate the power of credentials in the intellectual marketplace; they are a rhetorical resource in the negotiation of knowledge claims. By manipulating this resource "intellectual leaders" exercise <u>both</u> the gatekeeping of claims and the opinion leadership in validating them as advances in knowledge. This manipulative skill is a definite art of the (elite?) scientist's craft.

33. Several details of the instrument are noteworthy. First, appended to each questionnaire was a personalized computer-generated cover sheet which asked the respondent to verify the year, discipline, and institution of Ph.D. as well as the publication information we had retrieved from library sources. The principal sources were Dissertation Abstracts (whose entries constituted our sampling frame) and the Source Index of the Science Citation Index (in which publications and most current addresses were found). Although the most comprehensive source of information on Ph.D.'s, the Doctorate Records File, proved unworkable, the National Research Council's Commission on Human Resources did cross-check our sample against the DRF, eliminating errors of commission, but not of omission. Our underestimate is very small, however. Second, we pretested the instrument on a sample selected by a consultant in each discipline. This resulted in vast improvements in format and content. The mailed version was still longer than we preferred, taking most some minutes to complete. Third, the personal biography-publication page—which took two forms (one for "researchers," another for "non-researchers")—plus our cover letter and persistence yielded a good response (see note 36; Chubin and Porter, 1980).

34. The social sciences were just embarking on new Ph.D. programs or beginning to graduate the first cohorts from them. Sociology, for example, increased its doctorate output by 50 percent from 1969 to 1974. By 1973-74 the glut of unemployed Ph.D.'s was a somber reminder that those programs were ill-timed, especially since, unlike economics, there was an undeveloped nonacademic market to absorb old and newly-minted Ph.D. sociologists.

35. In standard demographic terms, the problems is one of gauging the relative impacts of "cohort effects" and "period effects" (see Ryder, 1965) on professional behavior. Note, too, that the life span of a scientist--with no mandatory retirement at age 65 and the availability of emeritus appointments--is now 40 years, not 35 as generally acknowledged (see Harmon, 1965).

36. The rate varied by discipline from a low of 64.2 percent in physics to a high of 79.4 in zoology. But the size of the "effective mailing" samples also varied with the sampling fractions that were dictated by the numbers of Ph.D. s produced in 1969-70. Our target sample size was 150 per discipline after "undeliverables" (e.g., address unknown) were subtracted. The effective mailing encompassed 922; a total of 645 usable questionnaires were returned, a response rate of 70 percent. Our persistence should not be underestimated. Through a sequence of two postcard reminders, a remailing of the entire package with a new cover letter, and follow-up phone calls, the response more than tripled the initial return of 20 percent. The initial mailing and follow-up procedures spanned four months (March-June 1979).

37. Interestingly, zoologists, who as an aggregate furnished the least commentary per capita, devoted the greatest proportion of their commentary to Question 10--over 43 percent (physicists were next with 36 percent).

38. The only departure from this ratio came from psychologists whose margin of positive to negative comments was 3:1. With the exception of the biochemists, over 90 percent of our cohort confessed little "serious conflict" with their supervisors. Ironically, over 90 percent of the biochemists coauthored with their supervisors, a proportion that is one-third to 3½ times the incidence of such coauthorship in our other disciplines.

39. Most of the other questionnaire items (e.g., biographical) and publication data are still being prepared for computer manipulation. (The numbers presented above were either computed by hand or extracted from analyses of a few select variables.) Consequently, the anecdotes reported below lack much of the contextual information that lends coherence to career patterns, i.e., as a sequence of motives, decisions, and organizational imperatives.

40. Long-distance and surrogate (i.e., unofficial) mentorship is apparently commonplace as similar admissions were made by respondents from three other disciplines as well. An electrical engineer proclaims: "My

dissertation was done under the unacknowledged guidance of an outstanding professor at another institution."

41. It is important to note that such admiration and praise for mentors was found by Krohn (1971:102-107) to vary by employment sector of the student. In general, his small sample of university scientists held their mentors in higher esteem than those in government or industrial jobs. Creativity, intellectual stature, friendliness, honesty, and the mentor's ability to excite the student's interest were the most-cited reasons for esteem.

42. One would suspect that such aversion promotes "ABD (all-but-dissertation) -itis." But for most so affected, the symptoms may appear well before the dissertation is contemplated. They drop out during the course work stage. This was the case with Bucher and Stelling's (1977:234-235) 1965 cohort of biochemistry graduate students. Only 10 of the 18 they studied completed their training and obtained Ph.D.s.

43. As a biochemist put it:

> You get what you put in or take out. It is not made by the advisor or the committee. They can keep you from making a fool of yourself, possibly. But by graduate level, one has embarked on a self-teaching effort for the most part.

A more typical view comes from a physicist: "My supervisor provided guided attention without a great deal of 'meddling'."

44. Specifically mentioned as attractions were "the influence of a particular faculty member there" (sociologist), "faculty strength in...taxonomy" (zoologist), and "the reputation of the university" (physicist). Overall, however, the availability of financial support was cited as more

important then the reputation of the department, the university, or of the department, the university, or of a faculty member--in that order--in the selection of a graduate institution. The only exception was found in zoology, where 63 percent of the cohort claimed that faculty reputation was decisive. Almost a third of the zoologists also rated the reputation of their mentor as "renowned" (top 5 percent nationally), as opposed to "eminent" (top 20 percent), "established," or "not prominent." This "renowned" proportion ranged from 13 to 23 percent for our other five disciplines.

45. Whitley (1977:32) conjectures that pressures toward specialization and narrowing of tasks and procedures can be ameliorated by "emigration to, and colonization of 'underdeveloped' areas," or by infanticide, i.e., the exportation of neophytes to other institutions such as industrial laboratories. "Infanticide" here refers to a disruption of the mentor's reproductive behavior. By dispatching academic students to nonacademic jobs, the students themselves are denied the opportunity to train students and perpetuate the genealogy for yet another generation.

46. Recall that Watson's (1968) autobiographical account of his pursuit and perception of the double helix was seen as a revelation of science's seamier side. The candor was refreshing and has seldom been equalled in its humanization of scientists (see Bernstein, 1978; Hixson, 1976).

APPENDIX N

THE DOCTORAL DISSERTATION:

Its Role in Research and Non-Research Careers

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In 1904 the Association of American Universities first enunciated the policy that "the PhD degree shall be open as a research degree in all fields of learning, pure and applied." This policy is still adhered to by the Council of Graduate Schools. The major distinguishing feature of doctoral education is the dissertation. The PhD dissertation is the final task of the doctoral student; it is supposed to be both original and independent research. Since its acceptance usually completes requirements for the PhD, the dissertation is the capstone of the graduate experience and a major factor in the research training of U.S. scientists (1). As a degree requirement it has remained essentially unchanged during a period when science has undergone radical changes, both intellectually (e.g., the transition from classical to modern physics and the emergence of molecular biology) and institutionally (e.g. the rise of "big science" in the university and the development of both national laboratories and large scale corporate R&D).

The PhD represents a certification or "union card" for the beginning research scientist. But this certification extends beyond research to areas where the typical PhD program offers little, if any, training. The PhD degree is usually required to enter the teaching ranks at four-year colleges and universities, although research requirements in some such positions may be minimal to non-existent. Likewise, the PhD is a qualification for certain entry level positions in R&D organizations of some government agencies and private firms -- careers that may be mainly managerial.

Since PhDs are trained in academia, their role models (2) and inculcated values tend to be academic, and the standard by which academic PhD scientists are routinely evaluated is their research output. The academic norm seems to encompass all scientists in a value system that places primary importance on research and publication. Yet, studies indicate that many PhDs never publish (3), suggesting that they are not involved in research either. Thus, it appears that for many PhDs science is a non-research activity in which work and rewards depart sharply in character from the academic norm.

Questions logically flow from the apparent disparity between the education of PhD scientists, with its emphasis on research, and the actual work of PhD scientists. To what extent does the academic model hold true and to what extent do PhD scientists actually pursue research-oriented careers? How well does graduate science education in the United States prepare PhDs for research and non-research careers? In this paper we address such questions, focusing on the doctoral dissertation because of its central role in the training of PhD scientists.

The value of the dissertation as a training device, even for those planning a research career, is not without its detractors. For example, in assessing the value of the dissertation for biologists, Reid (4) argues that: 1) it is not a useful tool in scientific communication; 2) it is a poor educational tool; 3) it places an undue burden on the doctoral student; 4) it is not evaluated by widely accepted standards; and 5) it does not generate publications, even if of high quality. Reid further suggests that the dissertation may be dysfunctional for the student since it is a long monograph and biologists publish short articles. Thus it does not provide training in the normal scholarly pursuits of the field. One physicist has blamed the constraining nature of dissertation evaluation practices for his failure to invent the laser (5). Also, a former president of the Institute of Electrical and Electronics Engineers has argued forcefully that "the present design of advanced engineering education does not meet the needs of the engineering manpower marketplace" (6). These concerns derive from an academic perspective; the pertinence of the dissertation to those who will pursue non-academic careers is even more problematic.

In light of such criticisms and in search of policy-relevant data, we undertook a two and one-half year study, supported by the National Science Foundation, to assess the research productivity and training effectiveness of the doctoral dissertation. Specifically, we addressed the following issues:

- o The quality of dissertation research;
- o The relationship between the dissertation and post-doctoral research;
- o The need for modification of the research orientation of the PhD degree or for replacement of it with training in other creative and marketable skills;
- o Alternative, more efficient ways of training graduate students for the broad spectrum of careers pursued by doctorate scientists.

Our operating hypothesis was that the dissertation would be perceived as valuable training by those actively engaged in research and as not so valuable by those pursuing non-research careers. In this paper we summarize the results of our study of 1969-79 PhDs in six disciplines, and we suggest implications for U.S. graduate science education policy.

STUDY DESIGN

The disciplines studied span the National Research Council (NRC) categories of science-based doctorates: physics (a physical science); biochemistry (a basic medical science); zoology (a biological science which is not a basic medical science); electrical engineering (an engineering science); psychology (a behavioral social science); and sociology (a social science). To generate a sample we randomly drew about 400/field (2438 names) who received their doctorates in 1969 or 1970, as reported in Dissertation Abstracts. The NRC matched this list with their combined work tape to eliminate persons with duplicate last names and initials. We then randomly selected to yield 200 per field, then sought addresses for these using the National Faculty Directory, various professional society directories (e.g., American Psychological Association), the Science Citation Index (SCI) and Social Science Citation Index (SSCI), and the institutions that awarded the PhDs.

Because the dissertation is part of a training process, we wished to trace its production back to the context of specific graduate education experiences and forward to post-PhD activities occurring within the first decade of the scientist's professional career. Our major sources of data were: 1) a mail survey in Spring, 1979, of the six-field sample of PhDs; and 2) a compilation of publication and citation information for the respondents to 1979. The self-reported data were designed to complement archival information in elucidating the mechanisms underlying career decisions and patterns. The survey elicited personal characteristics; doctoral training experiences, and respondents' assessment of these experiences; and work history. Respondents numbered 645, a response rate of 70% (7). Publication and citation information was gathered through a multistep process. First we searched SCI and SSCI for publications by our sample. Publications were keypunched, then reproduced as a special coversheet attached to each questionnaire. Respondents were asked to correct and augment the publication information (8), and to categorize the publications as: pre-dissertation, derived from the dissertation, resulting from continuation of the dissertation research, or other non-dissertation-related post-PhD work. Citation information was obtained from an automated search of the SCI for 1970 through 1978 by the Institute for Scientific

Information. Concurrently, we searched the SSCI by hand.

SAMPLE CHARACTERISTICS

Table 1 illustrates some of the principal characteristics of the PhD recipients who made up our sample. The relationship between undergraduate degree and field of graduate training varied widely by field. A substantial 93% of physics PhDs had bachelor's degrees in physics; only 29% of sociology PhDs had bachelor's degrees in sociology. Only 10.7% overall were women, ranging from a low of 0.9% among electrical engineers to a high of 24.3% in psychology.

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Table 1 About Here
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Respondents reported using a number of criteria to select a graduate school. The most significant was the availability of financial support, rated important (4 or 5 on a 5-point scale) by 59%. Following closely were reputation of the department (56%), reputation of the university (51%), situational factors (51%), and reputation in a specialty (50%). The median age at the doctorate was tightly clustered around 28, with the exception of sociologists (median age 33.3). Median time from bachelor's degree to doctorate varied from 5.5 and 5.7 years for biochemists and psychologists to 9.1 year for sociologists. Despite their relatively short time in PhD programs, biochemists and psychologists represent the extremes of time spent on the dissertation, 23.9 and 9.5 FTE months respectively. The dissertation thus appears to play a larger - and earlier - role for biochemists: 74% of them began their dissertation in the early or middle stages of coursework for the doctorate vs. only 26% of the psychologists. The pattern seems to generalize with the social scientists devoting less time to the dissertation and starting it later, while the physical scientists spend more time and start earlier.

Federal financial support was quite important to this cohort of PhDs. Such support was most frequent in the physical sciences where the dominant mechanism was assistantships on research grants. Support was less common in the social sciences where fellowships were most important.

A postdoctoral appointment is another important stage in the neophyte scientist's career. The majority of biochemists held post-doctoral fellowships, as did a substantial minority of physicists and zoologists. Only a small minority in psychology, sociology, and electrical engineering undertook such appointments. In general, our respondents have spent the majority of their time since earning the PhD working in academe, except for the electrical engineers who have primarily been employed in industry. Physicists present the employment profile most evenly balanced across academe, industry, and government. At the other extreme, zoologists and sociologists are employed almost exclusively in academe.

THE RESEARCH TRAINING PROCESS

We were able to obtain Roose-Anderson peer ratings (9) for the departments from which most (93.6%) of our respondents graduated. Of these respondents, 37% came from departments rated good to strong; 35% average to good; only 12% had faculty ratings from strong to distinguished. Respondents who graduated from higher rated departments perceived reputation of the university, of the department, and of the specialty area as relatively more important in their selection of the particular PhD program. In contrast, the importance of faculty (intended dissertation supervisor) in the selection of one's PhD program generally was inversely related to departmental prestige (10). This suggests that, to some degree, PhD students are attracted to weakly rated programs by indiviual faculty members, and implies that students attending such programs may be more discerning, not less, than their peers at more highly rated departments (though one must beware a possible hindsight "halo effect").

A key factor in selecting a program or department is the candidate's aim in seeking the PhD. In Table 2, we summarize our findings, reported in full elsewhere (11), on features of the research training process. First, we observe that, for these respondents, research is only slightly more important than teaching as an aim in seeking the PhD degree (overall, 3.71 vs. 3.64 on 5-point scales). In psychology, sociology, and zoology, teaching is more important, and in psychology "professional practice" is indeed equally important to research and teaching. For 24% of the respondents, research was an unimportant aim (1 or 2). Thus we should not assume that all doctoral students are even initially pursuing research careers (12).

Table 2 About Here

The rhetoric surrounding the dissertation experience emphasizes the master-apprentice relationship between the student and the supervisor (13). Thus we asked a number of questions on supervision. Dissertation supervisors were perceived to be remarkably eminent ($\bar{X}$ = 2.66 on a 4-point scale where 4 (renowned) = top 5% nationally, 3 (eminent) = next 15%, 2 = established, 1 = not prominent). The supervisors were estimated to have guided a striking number of dissertations: mean = 12.5 (median = 6.2) to completion, with three others in progress. The strong impression, therefore, is that graduate students distribute themselves very unevenly among prospective faculty advisors. Indeed, they cluster around those perceived as outstanding.

Yet one might wonder how much supervision is provided. A substantial percentage (17.1%) rated the supervision they received as "minimal throughout" (1 on a 6-point scale); on the other hand, 24.2% responded "heavy throughout" or "almost daily" (5 or 6 on that scale). There was essentially no difference in the amount of supervision by the perceived eminence of the supervisor. Likewise, respondents felt inspired or stimulated by their supervisors to a considerable degree (median = 3.8; 59.4% responding 4 or 5 on a 5-point scale from 1 = not at all, to 5 = very much) (14). Support from peers and other professionals is notably stronger in the physical than social or engineering sciences studied.

Two other opportunities for supervisor involvement in the doctoral student's early career are publication co-authorship and aid in obtaining the first post-PhD job. Table 2 indicates that co-authorship practices vary dramatically by discipline from being the rule in biochemistry to relatively rare in sociology. Important assistance in obtaining the first job was attributed more often to biochemistry supervisors as well, with least assistance given in electrical engineering.

Finally, in Table 2 we report how our sample perceived the evaluation of their dissertations by supervisors and committees. The most important of five evaluative criteria was explicit demonstration of competence to do research in the field (mean = 4.2). Second was originality (3.7), followed by significance of the contribution to scientific knowledge (3.5), positive findings (3.2), and relevance of the research to practical applications (2.6). Across fields, originality and significance are most critical in zoology, least in the social sciences. The importance of originality also tends to increase as departmental prestige increases. Practical relevance displays field differences with the engineers considering it quite important and the natural sciences (physics, zoology, and biochemistry) almost ignoring it.

These ratings reflect the traditional dual role of the doctoral dissertation: the training and certification of scientists, and the production of scientific knowledge. In the next section we examine the value of the research products derived from the dissertation.

RESEARCH VALUE OF THE DISSERTATION

An earlier study of psychologists (16) suggested that the research yield of dissertations was high. To determine research merit of dissertations for the present sample, we compared the rate of citation of dissertation-derived publications to that of other publications by the same authors. In addition, the total number of publications was tallied.

On average, one publication per individual is derived directly from the dissertation and almost one per individual from continuation of the dissertation research (Table 3). The distribution of publications per individual is skewed, however. The 0.79 publications per individual derived from continuation of the dissertation research reflect the work of only about one-quarter of the sample. Combining publications resulting directly

Table 3 About Here

from the dissertation with those resulting from continuation of that research, we find 44% of the sample not publishing at all in either category; 18.7% publishing a single piece; 13.7%, two pieces; and 23.1% three or more to a maximum of 16 pieces. There also are substantial field differences. A majority in biochemistry, zoology, and physics publish from the dissertation; a minority in psychology, sociology and electrical engineering do so.

If published research has merit it should be reflected in the frequency with which it is cited by others (18). To compare citations, we adjusted the measure to account for uneven time intervals available for citation by employing a yearly rate. We also took logarithms of the citations to reduce the weight accorded very high citation rates (to make the measure more suitable for general linear model statistical analyses). Table 3 displays raw citation counts that indicate substantial differences by field and category. Analyses of variance confirm the differences as significant, with biochemistry the leader in citations per publication, and also in publications per person (19).

Publications directly derived from the dissertation lead all other categories on each of the citation measures. In particular, the log of yearly citations, controlling for field, shows a significant difference among categories ($\underline{F} = 4.86$; $p < .002$):

(1) pre-dissertation = .08 mean log citations/publication/year (N = 421)

(2) directly from dissertation = .13 (N = 561)

(3) continuation of the dissertation = .11 (N = 468)

(4) post-PhD, not dissertation related = .11 (N = 3164).

Field comparisons on this measure find publications directly derived from the dissertation more cited in every case (though significantly so only for physics and sociology). Simply put, dissertation-derived publications appear to be slightly more cited than other work by the same authors (20). Thus, it appears that there is real scientific merit to dissertation research.

Academics and those pursuing research-oriented careers derive more publications from their dissertations and continuation of the dissertation research than do non-academics and those pursuing non-research careers. In addition, quality of one's graduate training faculty associates with increased publication from the dissertation, and tends to do so for continuation of that research. Thus, the dissertation is far more than a mundane academic hurdle. It results in publications in half of the cases (yielding, on average, one direct publication per dissertation), and those publications accrue more citations than others by the same authors.

TRACKING BEYOND THE DOCTORATE

Twenty years of study of career patterns of scientists has generally portrayed scientists as a largely undifferentiated labor force that conducts physical science research in academic settings, gaining eminence from peer recognition of the research. Interest has focused on predicting scientific achievements in terms of such factors as ascription by one's origins (PhD program excellence, mentor eminence) (21). While we address such issues, we will also probe the hypothesis that the unitary research-oriented model poorly fits the 1968-70 PhD cohort.

Research Patterns

As shown in Table 3, 62% of the sample published work post-PhD not related to their dissertations, implying that 38% did not. Table 4 and Figure 1 elaborate on various dimensions of early career publication patterns. The cumulative percentage of respondents publishing shows a

Table 4 and Figure 1 About Here

rapid rise and quick tapering off, with 3 of 4 PhDs publishing during the first post-PhD decade. If one has not published within two years of receiving the PhD, (s)he is apt not to do so thereafter. Field differences are striking: in sociology, psychology, and electrical engineering, some 36% of PhDs never publish, whereas in the natural sciences, most do (all but 8% in biochemistry). The cumulative distribution of three or more publications at four intervals reinforces the finding that a substantial proportion of PhDs do not actively pursue research.

Publication patterns appear to be established early in one's career. For example, 154 respondents published three or more times in 1977-79. Most of these had been highly productive earlier in their careers: all but 18 published 2 or more pieces in 1974-76, all but 27 produced at this level in 1971-73. Conversely, of 238 respondents failing to publish in 1971-73, 190 did not publish in 1974-76, and 185 of these 190 did not publish in 1977-79. A rather clear and stable distinction between researchers and non-researchers can be traced in these data.

Returning to Figure 1, it is instructive to consider annual publication rates. For the sample as a whole, output increases slightly over the course of the decade. On average, this reflects almost 1 publication/PhD/year, but in reality only about 40% of the sample publishes in a given year. For years 1976 and 1977 (taken separately, then averaged), 16% published a single piece and almost 22% authored multiple publications. These 22% of the PhDs account for 82% of the publications!

The field profiles in Table 4 also suggest that the percent publishing in a given year is lower in engineering and the social sciences. Only electrical engineering shows a sizeable drop from 1971-72 to 1976-77. The profiles again suggest a rather stable, even increasing (N/publishing person in Figure 1 and Table 4), commitment to research by a minority of the sample. However, while the natural sciences and engineering show small trends upwards in publications/person, psychology and sociology show small downtrends. Figure 2 explores the issue by contrasting the 1969-70 psychologists in our sample to a cohort of 1963-64 psychologists (16).

Two observations are in order. First, both cohorts show a rise, then a

Figure 2 About Here

decline in research output. Second, the maximum level of output is considerably lower and the peak publication period is substantionally shorter for the later cohort (22). These observations are potentially of great import. The former indicates a rapid falling away from research interests. (Table 4 and related data imply that this is more a function of fewer people actively continuing to pursue research than of the same number of researchers producing less.) The latter suggests a decline of average research output per PhD where we expected an increase in accord with increased pressures to publish contributing to the "information explosion." If PhDs in psychology, and possibly sociology, are indeed abandoning research, we need to find out why, as well as which work roles and sectors they are embracing (23).

Measures other than publication counts also affirm a waning involvement in research. In response to a query as to primary 1979 work activity, 38.6% of the 1969-70 PhDs indicated research or a combination of research and teaching - a percentage remarkably similar to the percentage publishing in any given year. On the other hand, 19.3% nominated teaching; 17.9% administration, or administration and research or teaching; and 24.2%, other. Of those reporting research as primary 1979 work activity, the percentage publishing in a given year had increased over time from 58% in 1971/1972 to 64% in 1976/1977; conversely teachers dropped from 28% to 24% over that time; administrators, from 34 to 27%; and others, from 32% to 16%. As for the time devoted to research on the present job, the mean response was 33.7% (median, 24.9%) with 39% spending 10% or less and 42% spending 33% or more. These figures are consistent with a recent NSF study reporting that science and engineering faculty spend one-third time in research (24). However, there is a bimodal distribution: many PhDs simply do not do research. While some would derogate non-research roles as embraced only by those unable to perform research effectively, we have noted that many PhDs never harbored research aims (c.f., Table 2). The attraction of non-research roles, such as administration, is supported by such factors as significantly higher salary and supervisory responsibility (11).

Predicting Research Commitment

We conceived of the training of a researcher as a process wherein: 1) career aims affect choices of graduate program and dissertation topic; 2) graduate training factors, mentor influences, and prestige of program mediate research orientation; 3) quality of dissertation experience links to continuation of that research and taking a post-doctoral appointment; and 4) all of these might combine to predict the extent of early career research dedication. Through a series of regression analyses on various career features (e.g., publication and citation counts, percent time on research, salary, supervisory responsibility) and on intermediate factors (e.g., supervisor aid in obtaining first post-PhD job, taking a post-doctoral appointment, continuing the dissertation research), we developed a general model (11) that, in particular, suggests:

- Initial inclination toward research and an academic career is positively associated with satisfactory graduate training experiences and research-oriented post-doctoral careers.
- Close relationship with dissertation supervisor seems to contribute to supervisor assistance in attaining the first job, continuation of the dissertation research, and taking a post-doctoral fellowship. It also relates to a "good" dissertation experience (e.g., chosen for and evaluated for

scientific importance, resulting in publications, and favorably judged by the respondent).

- These factors, including initial orientation to research and to an academic career (but excepting continuation of the dissertation research), are associated with continuing commitment to research.

Table 5 presents summary regressions on two of the key early career research indicators: $\log_{10}$ of 1976-79 publications and percent time devoted to research in 1979 (correlation between these is .56). Percent time on research on the first post-PhD job is a strong predictor of later research commitment. (This is a potentially useful "science indicator" in that the NRC's Survey of Earned Doctorates taps such a measure.) Early publication is the other strong predictor. Two other predictors deserve special consideration. Roose-Anderson ratings of PhD departmental quality relate to later research effort, with high publishers emerging from both high rated groups of departments (means of 10.0 and 9.7) relative to the two lower-ranked groups (6.9 and 5.4) (9). Post-docs are especially germane to the natural sciences; furthermore, they bear policy implications because they are directly liable to availability of funding. Field does not dominate the regressions, despite the different levels of research observed in, say, biochemistry and electrical engineering. Neither is supervisor prominence a dominant factor.

Table 5 About Here

RESEARCHERS, NON-RESEARCHERS, AND THE DISSERTATION

How does the dissertation experience differ for future researchers and non-researchers? To what extent does it meet the needs of each? We hypothesized that the dissertation would be perceived as training worth the effort required by researchers, especially academics, but not so by non-researchers. First, we profiled those who have pursued academic careers as a separate group. Next we compared researchers to non-researchers who have followed academic or non-academic career orientations. Finally, we analyzed administrators and teachers separately. Most all of the analyses pointed toward similar conclusions: that while graduate training/dissertation experiences and their retrospective evaluations diverge somewhat, overall there was a consensus of support for current practices.

Table 6 contrasts those who report research (or research and teaching) to be their primary work activity with teachers, administrators, and others. Graduate training experiences certainly differ significantly in a statistical sense. Specifically, future researchers, as compared to non-researchers

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Table 6 About Here
- - - - - - - - - - -

(summarized in Table 6 (see also 11):

- are younger when they receive the PhD (and take 1.5 years less from their bachelor's), yet spend longer on their dissertations and in their doctoral programs;
- receive more financial aid - fellowships/traineeships, as well as grant support - and enter employment more closely related to their dissertations;
- seek the PhD more for research reasons and weight reputational factors slightly more heavily in selecting a graduate program;
- choose dissertation topics more on scientific merit, less on manageability;
- see their dissertations as having been evaluated more stringently

on significance, originality, and positive findings; less, on practical relevance;

- reported their dissertations as relatively more empirical than theoretical, lab than field, basic than applied;
- rated their supervisors (mentors) more eminent, yet having guided relatively fewer dissertations to completion (mean of 10 vs. 14), but researchers had received non-significantly less supervision and more stimulation;
- had better resources - reporting more help from peers, professionals, and seminars; marginally better research facilities, and higher rated departments.

Within-field analyses of variance typically show that differences are rarely significant and quite variable across fields. (Also, variance accounted for in regressions was higher within than across fields.) Indeed, as Table 6 indicates, the overall results, while highly statistically significant, are not large. $\underline{\omega}^2$, the proportion of variance in the entire score distribution accounted for by the categorization (researcher, teacher, administrator, or other), averages 2.6% for the tabled graduate training experiences; $\underline{d}$, the number of standard deviations by which researchers differ from all others taken together, averages .30 in magnitude (a $\underline{d}$ of .2 can be taken as small, .5 medium, and .8 large) (25).

As for evaluations, satisfaction with one's graduate training is slightly higher for researchers than for non-researchers. More impressive is the perception of one's dissertation as generally valuable, a single questionnaire item scaled from 1 to 5, with both researchers and non-researchers averaging greater than 4 (median for all respondents is a striking 4.32 with only 5% of respondents below 3).

All responses pertaining to current practices indicate general satisfaction, with largely insignificant differences among the groups (Table 6). Possible changes in current practices garner no substantial support. Refining the categorization to focus on those we suspected might be most disapproving of the dissertation - clinical psychologists ($\underline{N}$ = 47) - reveals a profile only slightly less supportive than non-researchers as a whole (e.g., general value of the dissertation 3.70 vs. 4.08 - lower, but still well on the positive side of the neutral point 3.0). Contrasting clinicians with other psychologists produced a significant difference on only one of the possible modifications of dissertation practices, with clinicians less negative on a practicum or internship in lieu of the dissertation (mean of 2.84 vs. 2.61 for "non-lab" and 2.04 for "lab" psychologists). On only one item do the clinical psychologists reach even the neutral point toward advocating change - a mean of 3.1 on alternative doctoral degrees.

A final testament to the breadth of support for the PhD dissertation requirements comes from a companion study that entailed interviews with 25 ABDs (persons who had completed all requirements for the PhD but the dissertation before leaving graduate school) from the fields covered in this study (14). Qualitative analysis of these interviews found that a large majority of the people interviewed believed that a dissertation should be required for receipt of a PhD degree. The rigor of the exercise was one of the reasons commonly cited; a frequently expressed view was that a research project on the scale of the dissertation teaches respect for the scientific method in a way that nothing else would or could. These endorsements are remarkable because they often come from people who have suffered professionally from the lack of a PhD. On the other hand, these individuals chose to enter PhD programs, and it must be assumed that they knew what was required and accepted the value of the dissertation. Thus, ABDs may perceive not completing the dissertation to be a reflection of their own failure and not the system's -- consequently, enhancing the value of the dissertation.

CONCLUDING OBSERVATIONS

These results confirm that, for U.S. universities around 1970, the PhD is truly a research-oriented degree. The dissertation occupies fully 39% of the total full-time equivalent time devoted to the degree. The yield from this effort is publishable research at least as highly cited as other work produced through the researcher's first professional decade. However, only a minority of those attaining this degree actively pursue research careers.

How well does this single-purpose degree serve the diverse needs of its recipients? Looking back after a decade, these PhDs perceive the doctoral training process quite favorably and are not disposed to change it. This is somewhat puzzling in the case of those not oriented toward research (who are slightly less favorably inclined). To what extent does the dissertation contribute to professional performance in other than research ventures? This study contributes one piece of evidence - that non-research-oriented PhDs, and also ABDs, perceive it favorably. It does not resolve why this is so and whether it is justified. However, it may be a reflection of "research reverence" -- a value system which allocates the greatest prestige rank (but not necessarily the greatest financial rank) to those who conduct research. Also, those who have been "bathed in the blood of the lamb" have a valued credential, particularly in a tight marketplace. The PhD degree may serve as a screening device, even for jobs where it has no relevance. It seems desirable to study whether linkages between dissertation training and later research management skills, teaching performance, clinical abilities, etc., are demonstrable. The face validity of these is questionable.

Additional research policy concerns arise from the study. There is a troubling decline in perceived quality of research facilities from graduate training to work setting a decade later. This was also observed for the 1963-64 cohort of psychologists (11), and is at least partly attributable to a movement "downward" from PhD training to work opportunities. Troubling also is the profile of psychologists to lowered research productivity within a decade of the PhD and also from the 1963-64 to 1969-70 cohorts.

Finally, within the framework of PhD education, there may be room for modifications to accommodate better the heterogenous career paths followed by graduates. Heightened sensitivity to non-academic markets and suitable skills may be necessary to sustain areas, such as the social sciences, facing low demand for PhDs from conventional academic markets, and also in areas, such as computers and certain engineering fields, facing high demand for pre-PhDs that seems to be choking off the supply of PhD students. Respondent suggestions included: greater involvement of industrial professionals in PhD dissertations; placing greater emphasis on research management training opportunities in conjunction with conduct of the dissertation; emphasis on group work more apt to match non-academic work settings; and reduction in the research investment inherent in the PhD, allowing postdoctoral appointments to polish research capabilities as needed. In sum, our respondents might caution against drastic changes in doctoral programs, but further study and experimentation to achieve, with the limited resources available, the most possible for a heterogenous group would appear desirable.

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7. Non-respondents differed from respondents only slightly, primarily in terms of publishing slightly less (mean initial count of publications of respondents 6.46, of non-respondents 5.96, and of those for whom addresses were unobtainable 4.81). On essentially all attributes, our sample matched the NRC tabulated population attributes closely. The sole notable exception is an undersampling of women in zoology due to a cumulation of having fewer in our random sampling than expected, more difficulty in obtaining addresses, and a lower response rate than for men. Respondents as a percentage of fiscal year 1970 doctorates awarded, based on NRC information, comprise: physics - 5.7%; biochemistry - 20.5%; zoology - 36.1%; electrical engineering - 15.0%; psychology - 5.7%; and sociology - 18.4%. Weighting of responses is not helpful because there is no best way to weight the fields to represent doctorate holders in general.

8. The wording varied according to the number of publications we had retrieved. Those showing 1 or 2 publications were asked to correct/augment, but the cover letter emphasized our interest in non-researchers, different from the cover letter for those with more publications. Those with 0 identified publications were not asked about publications. This implies a biasing toward under-reporting their publications, tradea off for an enhanced response rate since our previous study indicated a tendency to undersample those less oriented to research (A. L. Porter and D. Wolfle, "Utility of the Doctoral Dissertation," American Psychologist 30, 1054-1061 (1975).

9. Charles Andersen of the American Council on Education kindly provided us with the explicit scale scores on rated quality of the graduate faculty for departments in our six fields from A Rating of Graduate Programs by K. D. Roose and C. J. Andersen (Washington, D.C., 1970). He recommended that measure over the rated effectiveness of doctoral programs as highly correlated but more valid.

10. Interestingly, in an analysis of variance of the importance of a particular faculty member in the selection of a PhD program (a 1-5 scaled rating) by field, sex, and departmental rating, all three main effects are significant. Particular faculty are a more compelling factor for zoologists (adjusted $\bar{X} = 3.65$) and less for the sociologists (2.35), physicists (2.22), and psychologists (2.18) - with electrical engineers (2.99) and biochemists (2.79) in-between. Women (adjusted $\bar{X} = 2.26$) weigh individual faculty less than do men on average (2.80).

11. A. L. Porter, D. E. Chubin, M. E. Boeckmann, T. Connolly, F. A. Rossini, A Cross-Disciplinary Assessment of the Role of the Doctoral Dissertation in Career Development, Final Report on Grant No. SRS78-18959 submitted to National Science Foundation, Division of Science Resources Studies, 1981.

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As F. Bowers [AAUP Bullentin, 366 (Winter, 1970)] puts it: "I do not know ... whether the essential training of the research elite to develop their peculiar capabilities is worth what is, no doubt, the over-training of the majority of those who shortly discover that they have no marked talent for continued original research of any magnitude."

13. H. Zuckerman, Scientific Elite: Nobel Laureates in the United States (Free Press, New York, 1977).

14. From our companion study of ABDs (P. Jacks, D. E. Chubin, A. L. Porter, and T. Connolly, The ABCs of ABDs: An Interview Study of Incomplete Doctorates), lack of supervisor support and financial exigencies were the two most-cited reasons for not completing the dissertation.

15. If we consider the factors contributing to the selection of a particular dissertation topic, the ideal might be student dedication to producing a major scientific contribution, as balanced against feasibility, and faculty preference. Our findings rank factors as follows: 1) Inherent personal interest (mean 3.7 on a scale of 1 = not important to 5 = very important); 2) scientific importance (3.4); 3) faculty preference (3.1); 4) manageable study (3.1); and environmental considerations (e.g. financial assistance, lab facilities) (2.9). Thus, it appears as if graduate students balance a number of factors, but the ordering favors student scientific interests over performing a research exercise to fulfill requirements or someone else's interests.

16. A. L. Porter and D. Wolfle, American Psychologist 30, 1054 (1975).

17. Our estimates corroborate a University of Michigan study [Dissertation Review Committee of the Rackham School of Graduate Studies, The Role of the Dissertation in Doctoral Education at the University of Michigan, Ann Arbor, 1976] of faculty estimates, which were lower than alumni reports on the amount of dissertation research reaching publication. They rationalize the discrepancy by noting that faculty may be unaware of some later publication while publishing alumni may be over-represented in the survey response. The values reported are (faculty estimate first, followed by alumni reports): life sciences - 65%/80%; physical sciences - 65%/78%; and social sciences - 36%/71%. These compare with our averages of percent publishing directly from the dissertation research: biochemistry and zoology - 66.4%; physics - 60.2%; and psychology and sociology - 27.8%.

18. J. R. Cole and S. Cole, Social Stratification in Science (University of Chicago Press, Chicago, 1973). For different viewpoints, see A. L. Porter, Social Studies of Science 7, 257-267 (1977); J. Margolis, Science 155, 1213-1219 (10 March 1967); E. T. Morman, 4S Newsletter 5, 7-13 (Summer 1980).

19. The automated citation counting of SCI appears to have slightly under-enumerated citations. Cross-field comparisons are imperfect inasmuch as sociology and psychology incorporate manual counts from the SSCI; however, the large field differences and the cross-category comparisons within field should be robust.

20. Dissertation-derived publications are also significantly more apt to be single-authored than other publications: with 1 = single-authored and 2 = multiple-authored, categories 2 and 3 mean, 1.64; category 1 = 1.70; category 4 = 1.82). This seems counter-intuitive to the notion of close guidance and collaboration with PhD supervisors.

21. D. E. Chubin, et al., American Sociological Review 46, 488-498 (August 1981).

22. Samples of 20 from each psychology cohort and from the biochemists were tracked through 1980 using only SCI to be sure the patterns were not artifacts of our counting method. The general profiles were confirmed. Biochemistry publications showed a minor peak in 1969, followed by an annual trend upward for 5 years, then held at a high level. The 1969-70 psychology subsample peaked at a low level in 1970, then dropped off steadily. The 1963-64 psychologists showed an increasing level for 5-6 years, then a sharp decline; but they produced considerably more than the 1969-70 psychologists. Publications for both groups of psychologists declined sharply from 1977 to 1980. Response bias toward active researchers was greater for the 1963-64 cohort; however, this does not appear sufficient to account for the observed magnitude of differences in research activity - see A. L. Porter, et al., in (11).

23. On the age-relatedness of research productivity, see A. Bayer and J. E. Dutton, Journal of Higher Education 48, 259-282 (May/June 1977); and A. Bayer, H. Zuckerman, and R. K. Merton, in A Theory of Age Stratification, Vol. 3, Aging and Society, M. W. Riley et al., Eds. (Russell Sage, New York, 1972).

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25. J. S. Hyde, American Psychologist 36, 892-901 (1981); J. Cohen, Statistical Power Analyses for the Behavioral Sciences (Academic Press, New York, 1969).

26. This research was supported by NSF grant SRS78-18959. Any opinions, findings, and conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views of the National Science Foundation, Georgia Tech, or the Urban Institute.

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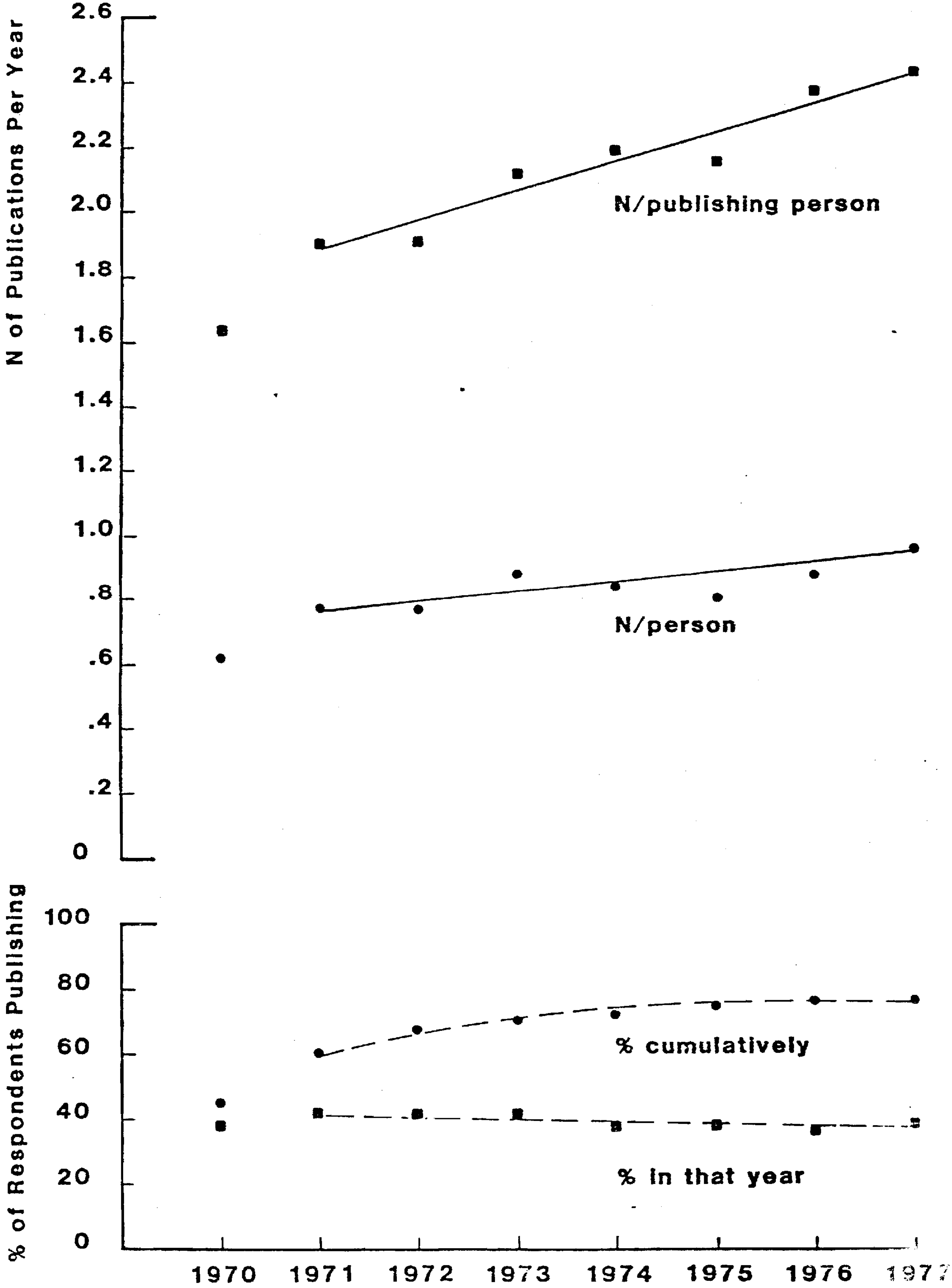
Figure Captions

Figure 1. Publication Over Time

Figure 2. Yearly Publication Rates

Legend: ● ———— 1963-64 Psychology PhDs

○ ········ 1969-70 Psychology PhDs



N of Publications Per Year
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
N/publishing person
N/person
% of Respondents Publishing
100
80
60
40
20
0
% cumulatively
% in that year
1970
1971
1972
1973
1974
1975
1976
1977

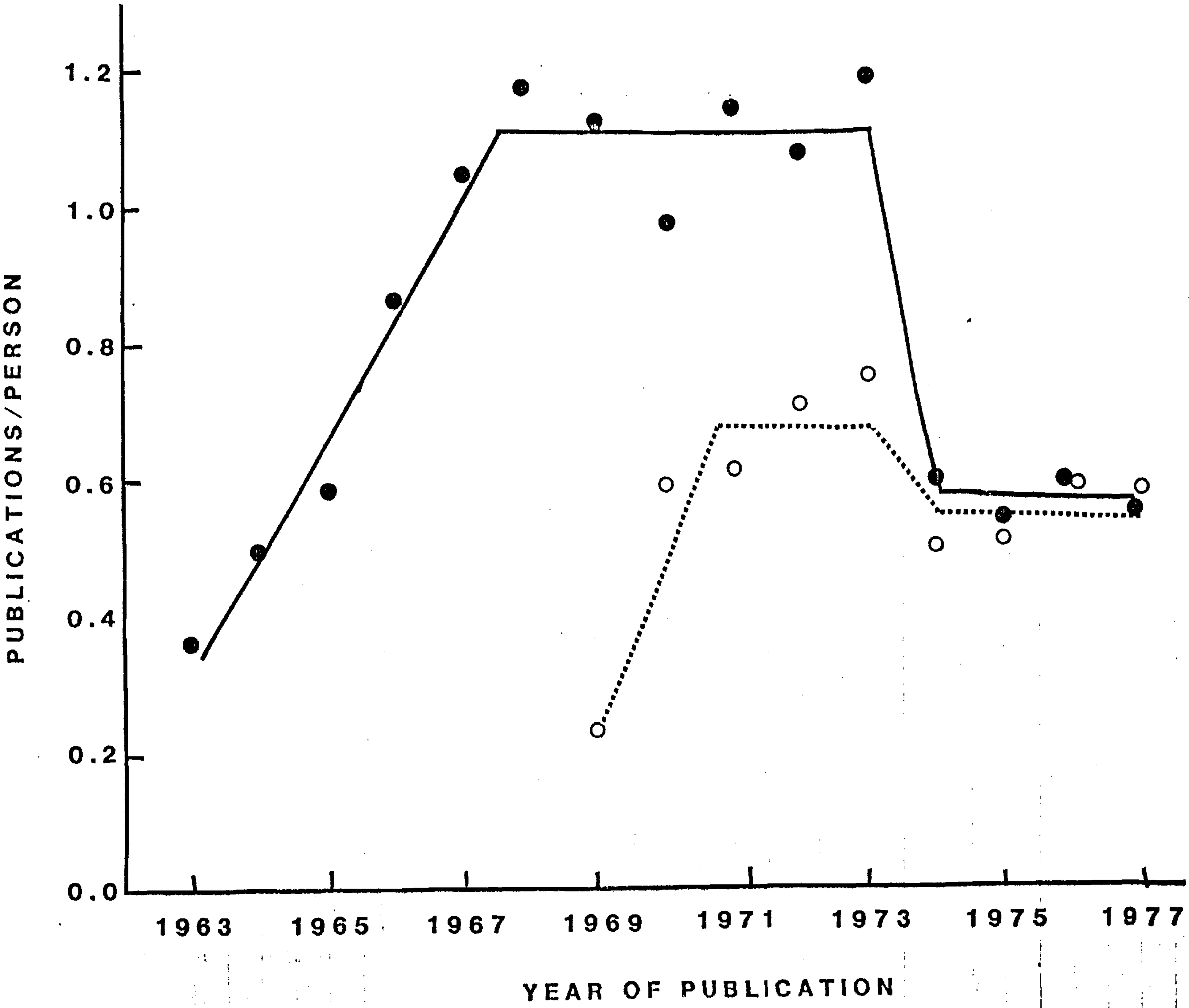

PUBLICATIONS/PERSON
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1963
1965
1967
1969
1971
1973
1975
1977
YEAR OF PUBLICATION

Table 1. Basic Respondent Characteristics

Field	N	% Female	% Married at Doctorate	Median Age at Doctorate[b]	Median Total Time from Bachelors to Doctorate[c] (Mean)	% with Masters Degree[d]	Median Full Time Equivalent (FTE) Months in Doctoral Program	Median FTE Months on Dissertation
Physics	97	2.1	84.5	28.9	6.8 (7.5)	81.4[d] (72.2)	50.8	23.8
Biochemistry	119	16.8	77.1	27.4	5.5 (6.4)	54.3[d] (42.0)	48.2	23.8
Zoology	123	2.4	78.7	28.9	6.6 (7.9)	84.5[d] (75.6)	42.2	20.1
Electrical Engineering	106	0.9	76.0	29.0	6.8 (8.1)	94.7[d] (84.0)	36.0	12.3
Psychology	107	24.3	71.7	28.2	5.7 (6.8)	84.4[d] (75.7)	44.9	9.5
Sociology	93	18.3	80.2	33.3	9.1 (10.3)	89.0[d] (78.5)	39.7	12.3
Total[a]	645	10.7	77.9	28.9	6.0 (7.8)	81.4 (70.7)	44.9	14.7

Field	Median Calendar Months on Dissertation	% Describing Federal Financial Support as Instrumental[e]: Grant	% Describing Federal Financial Support as Instrumental[e]: Fellowship/Traineeship	% Held Postdoctoral Fellowship or Temporary Research Assistantship	% FTE Employment in Academe 1970-79	% of Time Devoted to Research (± Standard Deviation): First Year Post-PhD Job	% of Time Devoted to Research (± Standard Deviation): 1979 Job
Physics	26.2	81.1	41.2	40.2	51.6	58.1±41.2	32.5±34.3
Biochemistry	29.9	89.1	73.1	72.3	64.8	85.0±30.2	57.3±31.6
Zoology	29.8	65.0	56.1	41.5	87.2	43.8±39.0	34.7±28.5
Electrical Engineering	18.4	56.3	49.0	9.5	27.1	43.1±34.6	24.6±27.1
Psychology	13.8	44.3	63.2	26.2	55.8	26.3±29.5	18.7±22.9
Sociology	18.1	26.7	32.6	18.5	88.7	25.5±24.1	30.9±26.6
Total[a]	23.9	61.6	53.7	35.9	63.4	48.0±39.5	33.7±31.3

[a] See Note 7

[b] We approximate by subtracting birth year from graduation year.

[c] Based on responses (N = 487) giving year of bachelor's degrees (when 2 such, we used the first listed), subtracted from graduation year.

[d] This value is probably an overestimate in that it is based on the responses to "Post-secondary degrees other than the PhD" (N = 560), and most non-respondents probably had no such degrees. The value in parentheses, on the other hand, divides the positive responses by the total field size and is an underestimate.

[e] Questions concerned whether federal fellowship or traineeship was instrumental to pursuit of the doctorate; whether federal research grant support (to self or faculty) was instrumental to dissertation work.

Table 2. Features of Research Training Process

Field	Preparing for Research-oriented Career Important in Seeking PhD[a] (%)	Preparing for Teaching Career Important in Seeking PhD[a] (%)	Inherent Personal Interest Important in Choice of Dissertation Topic[a] (%)	Faculty Preference Importance in Choice of Dissertation Topic[a] (%)
Physics	70.5	53.8	55.8	65.3
Biochemistry	81.4	49.1	48.3	68.6
Zoology	62.2	76.0	75.6	36.9
Electrical Engineering	58.4	39.6	60.6	48.1
Psychology	47.5	50.0	66.3	34.7
Sociology	40.5	76.4	66.7	40.7
Total	61.2	57.6	62.3	49.1

	Supervisor Involvement			Adequacy of Research Facilities[b]		Importance in Evaluation of the Dissertation[a]		
	Median Dissertations Guided to Completion	Co-Authorship	Important in Obtaining First Post-PhD Job[a]	Dissertation Research	Current	Originality	Significance	Positive Findings
Physics	3.6	65.3	31.2	81.2	56.2	55.9	54.9	46.1
Biochemistry	3.9	91.4	37.2	84.0	79.0	65.0	59.3	59.8
Zoology	8.0	45.5	26.5	74.6	47.6	73.0	61.5	48.8
Electrical Engineering	4.8	60.4	15.8	70.7	65.9	71.2	55.8	49.5
Psychology	9.9	44.3	20.2	74.8	40.3	51.9	43.8	33.3
Sociology	10.1	26.1	22.2	73.3	48.8	60.7	43.8	24.4
Total	6.2	56.6	25.9	76.6	57.1	63.4	53.7	44.6

[a] "Important" = responses of 4 or 5 on a scale from 1 = not important to 5 = very important.

[b] Adequacy indicated by responses of 4 or 5 on a scale from 1 = not satisfactory to 5 = very satisfactory. We note that a sizeable percentage of respondents indicated current research facilities to be "not applicable." If they were included in the total tally on the presumption that the facilities are not satisfactory, the percentage "adequate" would drop from 57.1 to 47.6 (in contrast, the drop for dissertation facilities would be slight, to 75.3%).

Table 6. Researchers vs. Non-Researchers: The Dissertation Experience

Variable	Research as 1979 Primary Work Activity mean	Other Than Research as 1979 Primary Work Activity mean	Differences ω^2	d	signif.
	[Items generally scaled (1) = not important or not satisfactory to (5) = very important or very satisfactory]				
Graduate Training Experiences					
Age at PhD (years)	29.4	31.1	.043	-.35	FAB
Full-time equivalent months on dissertation	19.6	16.2	.020	.09	FAC
Federal research grant support instrumental to dissertation - (1) = no; (5) = yes	3.92	3.21	.028	.36	FABC
Scientific importance a factor in choice of dissertation topic	3.67	3.24	.029	.38	FABC
Dissertation empirical/experimental (5) vs. theoretical (1)	3.70	3.42	.010	.24	FAC
Significant scientific findings important in the evaluation of one's dissertation	3.78	3.40	.031	.38	FABC
Dissertation Supervisor Prominence - (1) = not prominent to (4) = top 5% nationally	2.86	2.55	.026	.33	FAB
Seminars, research group meetings, colloquia helpful in dissertation work/doctoral training	3.40	2.86	.042	.41	FABC
Adequacy of research facilities for dissertation research	4.17	4.03	.010	.15	Fa
Quality rating of graduate faculty (Roose-Andersen)	3.12	2.85	.023	.31	FABC
Evaluation of Own Graduate Experiences					
Index of satisfaction with graduate training	4.40	4.21	.033	.25	FA
Index of perceived research value of dissertation	3.50	3.26	.026	.26	FA
Index of training value of dissertation	3.86	3.76	.003	.14	
Dissertation experience perceived as generally valuable	4.26	4.08	.014	.19	a
Evaluation of Current Dissertation Practices	[Items scaled (1) = too little, (3) = about right, (5) = too much]				
Emphasis on originality	2.67	2.65	0	.03	
Emphasis on obtaining positive (rather than negative) research results	3.30	3.43	.006	-.17	b
Emphasis on relevance to student's career needs	2.67	2.40	.019	.27	fA
Opinion of Possible Changes in Doctoral Requirements	[Items scaled (1) = strongly disapprove to (5) = strongly approve]				
Overall increase in standards and requirements	3.26	2.96	.013	.26	FABc
Several small-scale, original research exercises in lieu of the dissertation	1.98	2.29	.015	-.26	FA
Several short reports, more like articles, in lieu of the written dissertation; research as at present	2.69	2.63	.005	.04	
Extended practicum or internship activities to acquire professional skills in lieu of the dissertation (within a PhD program)	1.93	2.29	.025	-.28	FA
Option of alternative doctoral degrees (e.g., Doctor of Arts, Doctor of Engineering) not oriented toward research	2.38	2.81	.018	-.30	FAbC

Note: ω^2 and F relate to ANOVA for the 4 categories: Researcher (N = 244), Teacher (N = 121), Administrator (N = 113) or Other (N = 151) for 1979 primary work activity. N varies slightly for each variable. ω^2 reflects the proportion of total variance in the variable accounted for by the 4 levels of the primary activity factor, computed as:

$$\frac{\text{Sum of Squares}_{\text{FACTOR}} - (c-1)\,\text{Mean Squares}_{\text{ERROR}}}{\text{Mean Squares}_{\text{ERROR}} + \text{Sum of Squares}_{\text{TOTAL}}}$$

where c = levels of the factor; in this case, 4. Significance levels are shown as: F ($p \le .01$), f ($p \le .05$), or no indication ($p > .05$) for ANOVA; and, likewise for t tests, A/a between researchers and all others combined; B/b between researchers and teachers; C/c between researchers and administrators. The d values pertain to the comparison of researchers with all others combined (N = 385). d is a measure of the magnitude of difference between the 2 groups, computed as:

$$\frac{\text{Mean}_{\text{RESEARCHERS}} - \text{Mean}_{\text{OTHERS}}}{\text{Standard Deviation}}$$

Standard deviation is taken as the ungrouped data value since the statistic presumes equal standard deviation.

Indexes are evenly weighted item combinations. Graduate training index includes satisfaction with obtaining PhD, field, and area. Dissertation research value includes inclination to pursue dissertation research post-PhD, satisfaction with topic, and perceived research value. Dissertation training value index includes satisfaction with learning to do independent research, specific research skills, to write for scholarly publication, and other valuable professional skills.